THE CASEY-HEDGES CO.

THE CASEY-HEDGES

WATER TUBE BOILER

ROBB ENGINEERING WORKS, LIMITED

HORIZONTAL
VERTICAL

Robb Engineering Works, Limited
Catalogue No.
Please return promptly to the Catalogue Cabinet

THE CASEY-HEDGES CO.
CHATTANOOGA, TENN.

CATALOG NO. W. T. 8

THE

C-H

Water Tube Boiler

HORIZONTAL

VERTICAL

CAPITAL $1,500,000.00

THE CASEY-HEDGES CO.

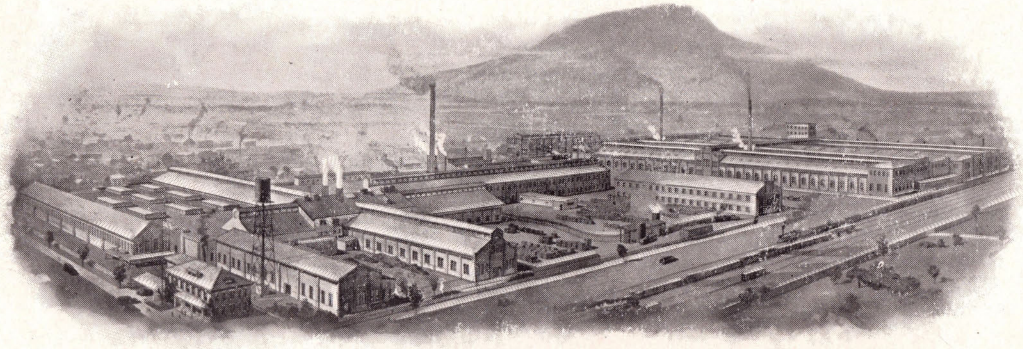
CHATTANOOGA

CINCINNATI
HAVANA
NEW ORLEANS

NEW YORK
SAN JUAN, P. R.
DENVER

CHICAGO
SEATTLE
MEMPHIS

CATALOG WT. 8



WORKS AND MAIN OFFICE
(Covering Fifteen Acres)
CHATTANOOGA, TENN., U. S. A.

CAPITAL AND SURPLUS, $2,000,000.00

THE CASEY-HEDGES CO. Inc.

Offices and Branches:

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SEATTLE
SAN JUAN

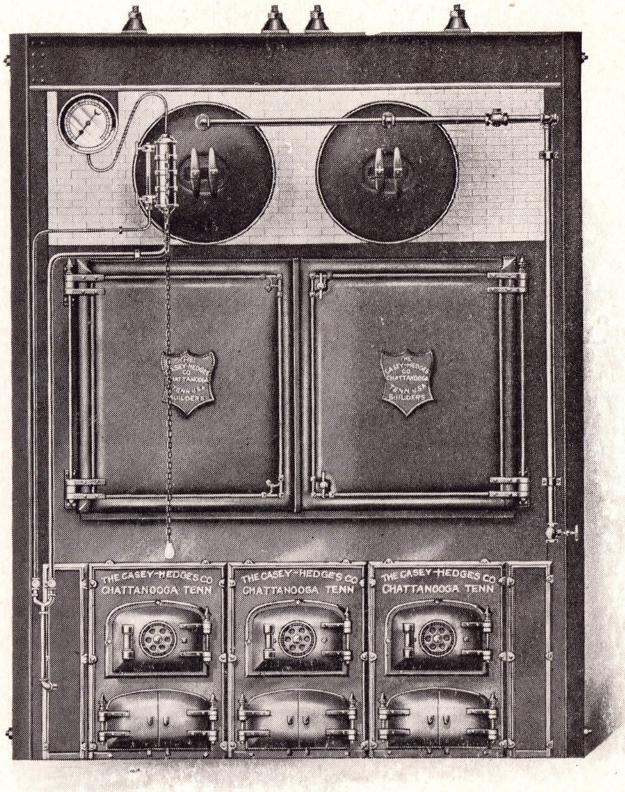
CHATTANOOGA
CHICAGO
NEW ORLEANS
DALLAS

CINCINNATI
MEMPHIS
HAVANA

Hendrie & Bolthoff Manufacturing & Supply Co.
DENVER, COL.

PRODUCTS

C-H Horizontal Water Tube Boilers
C-H Cross Drum Water Tube Boilers
C-H Vertical Water Tube Boilers
C-H Marine Water Tube Boilers
C-H Multitubular Boilers
C-H Internally Fired Boilers
Boiler Castings
Boilers Designed for any Special Purpose
Pressure Tanks
Heavy Steel Plate Work
General Foundry Work


THE CASEY-HEDGES CO. CHATTANOOGA TENN. U.S.A. BUILDERS
THE CASEY-HEDGES CO. CHATTANOOGA TENN. U.S.A. BUILDERS
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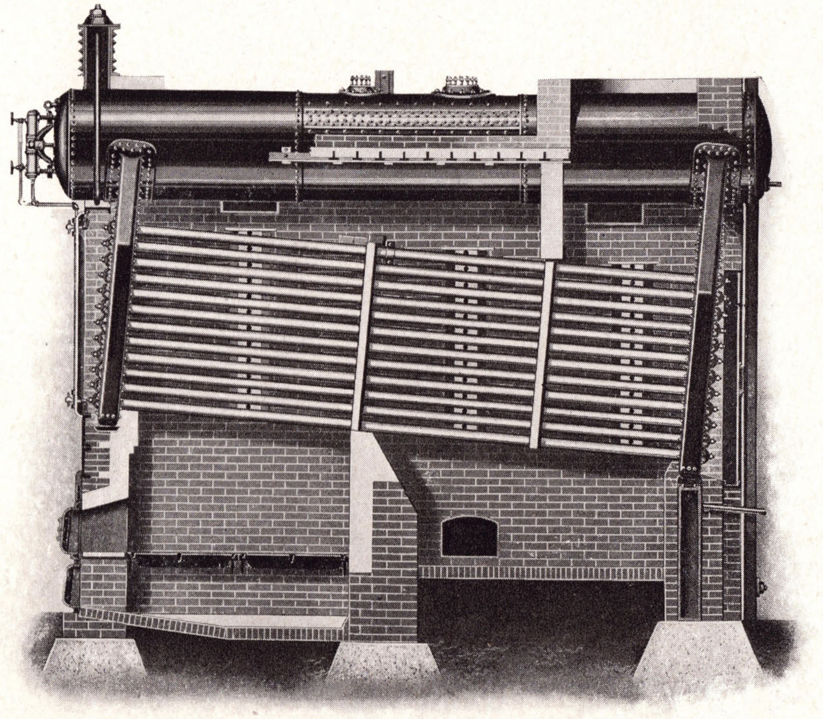
Front View C-H Horizontal Water Tube Boiler



Sectional View Through Brick Work Longitudinal Drum Type

The C-H Horizontal Water Tube Boiler

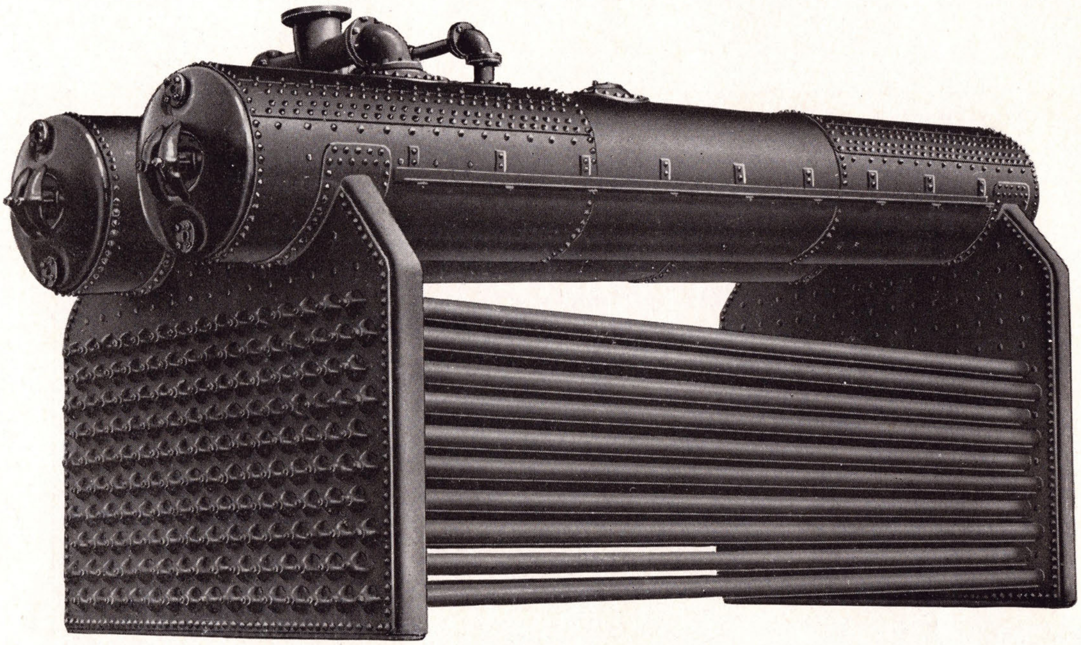
THE C-H Horizontal Water Tube Boiler is made in two types. The Longitudinal Drum type and the Cross Drum type. Both designs give satisfactory service in every respect and we do not hesitate in recommending them for any condition requiring a high pressure, economical steam generating unit. While the Longitudinal Drum Boiler has been the most popular in the past, we believe the Cross Drum Boiler will be in greater demand in the future, especially where boilers of large size are required.

The C-H Horizontal Water Tube Boiler is built along the lines of recognized standard boiler construction and it is free from experiments. The purchaser of a C-H Water Tube Boiler has the assurance that he is getting a steam producing unit that will give him entire satisfaction and that he is not being imposed on by the manufacturer in the purchase of a freak design.

LONGITUDINAL DRUM TYPE

The Longitudinal Drum type of boiler consists of one or more longitudinal steam and water drums, having attached to its lower portion at each end a forged steel water leg or header. These headers are connected together with inclined tubes, 4 inches in diameter and having a length ranging from 14 to 18 feet. (In our Horizontal Baffle Boiler, type C-1, we use $3\frac{1}{2}''$ diameter tubes). These tubes are expanded into drilled tube holes, the ends of which project approximately $\frac{3}{8}''$ inside of the header and are belled or flared out.

Transportation Building, Chicago, Ill., Equipped with 900 H.P. C-H Water Tube Boilers



A Double Drum Unit Ready for Shipment

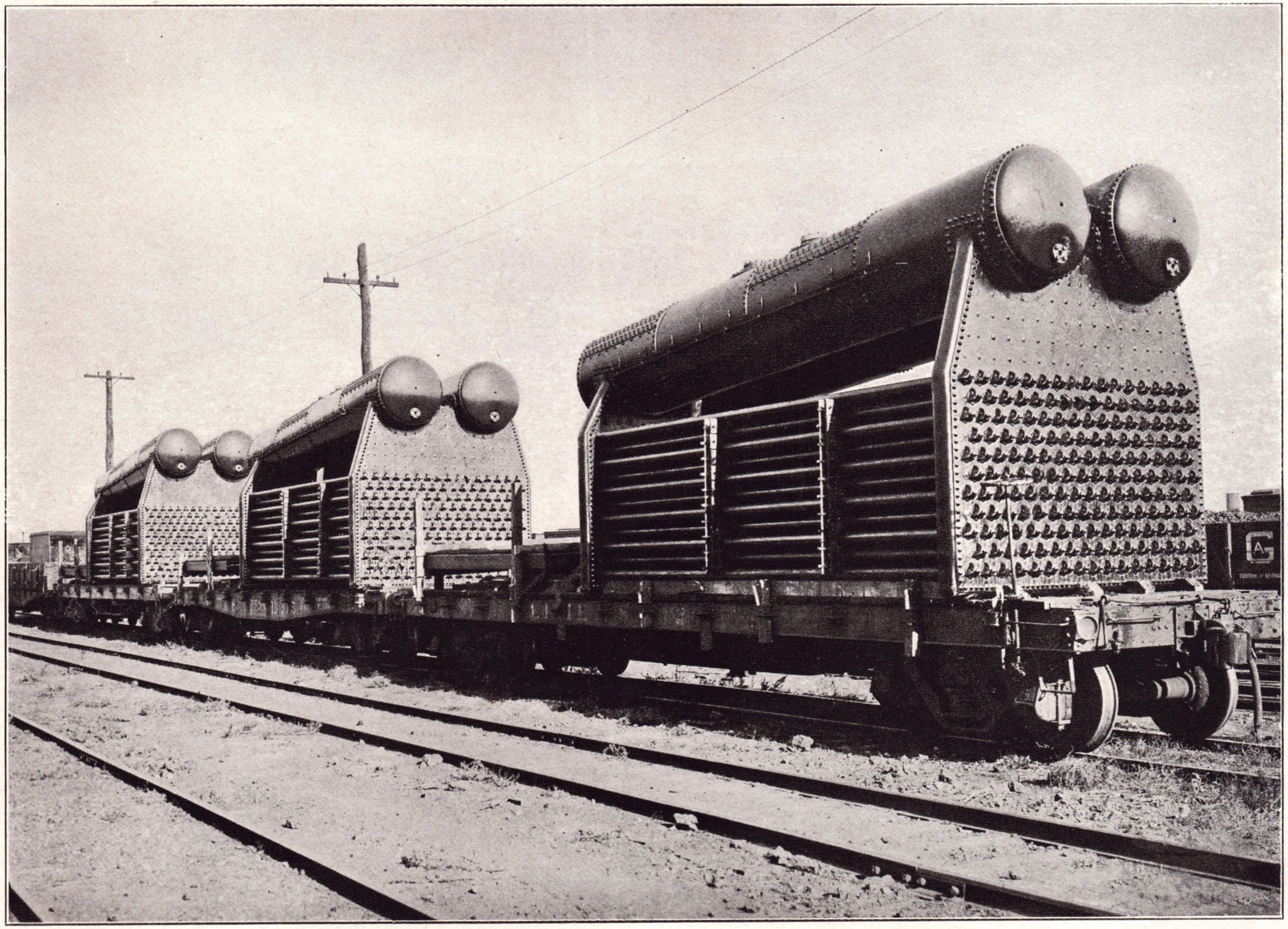
The drums are perfectly cylindrical and the shell sheets are of such thickness using a factor of safety of five so as to permit the maximum steam pressure for which the boiler is constructed to be carried. The longitudinal seams are of the Butt Joint type with inside and outside covering straps. No lap joints are used on longitudinal seams. The circular seams of the drum shells are usually single lap riveted, but on extreme high pressure boilers they are sometimes double riveted. All rivet holes are spaced to templets and guide holes are first punched small in the flat sheet and after this is done, the shells are rolled, assembled together with heads in place and the rivet holes are carefully drilled out to full size. All accessible rivets are driven by hydraulic pressure.

The drum heads are formed in a hydraulic press at a single heat. Heads with manholes have the manhole opening turned inwardly, the face of which is carefully machined off. Manholes are provided with forged steel manhole plates with forged steel arches and bolts.

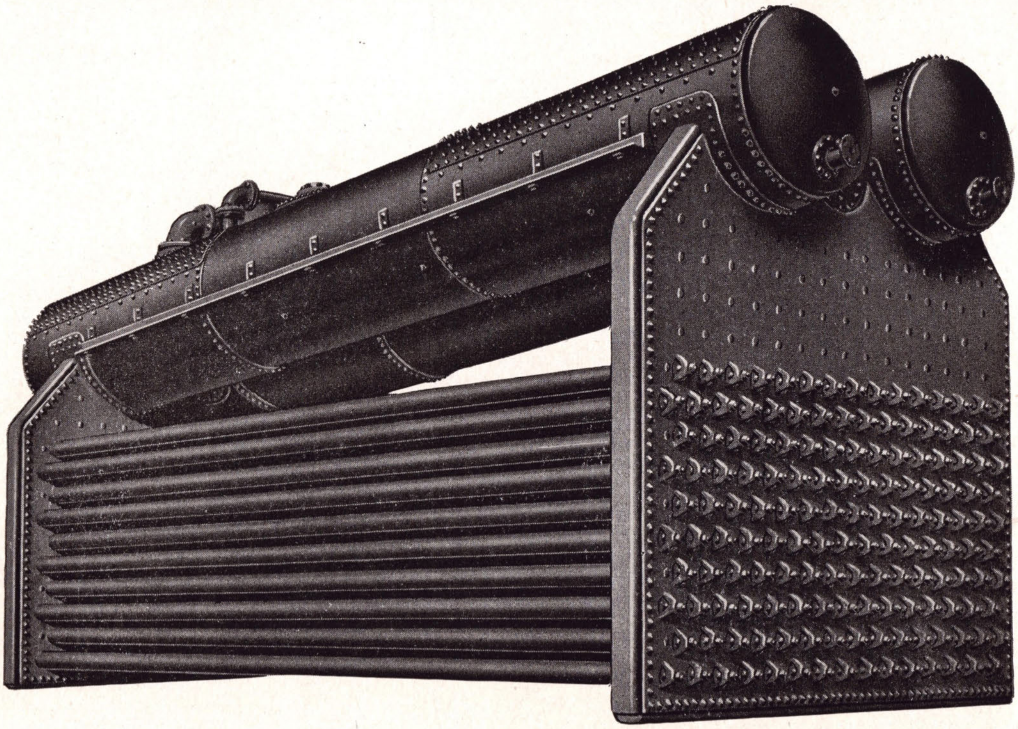
The studded nozzles on steam drums are of forged steel provided with taper thread stud bolts. The surface of the nozzles is carefully machined off.

Headers are of wrought steel and consist of a tube and handhole plate closed at the sides and ends with a special convexed wrapper sheet. Headers are thoroughly stay-bolted with refined iron or steel stay-bolts. The stay-bolts have holes in their outer ends 3-16″ diameter, drilled to a depth of 1½″. Stay bolts are cut to exact length and are headed over by a special machine. The construction of our headers is such that they are the strongest part of the boiler and there has never been an explosion or failure of a header on a C-H Water Tube Boiler. Opposite each tube, there is an oval shaped handhole opening. This handhole opening is closed by a heavy inside fitting forged steel handhole plate having a machined bearing surface for gasket. The shoulder on the handhole plate is square without a fillet and is at exact right angles with the machined bearing surface. The clearance between the shoulder of the plate and the header is approximately 1-32 of an inch. A thin gasket is used to make joint between the plates and header. Forged steel trypod pattern handhole arches are provided. The studs on the handhole plates have a finished hex nut with a heavy washer. The handhole plates being oval can be easily removed through the openings in the headers. Key handhole plugs will be furnished as optional equipment.

The interior of the drum is provided with a steel mud drum 9″ diameter, 10′ long. The feed water is introduced into this mud drum and most of the impurities in the water are deposited



Three 400 H.P. C-H Horizontal Water Tube Boilers for Papelera Cubana. (Cuba Paper Company)



Rear View of Standard Double Drum Unit

inside. Such deposits are blown off through an opening leading from the rear of the mud drum through the back boiler drum head.

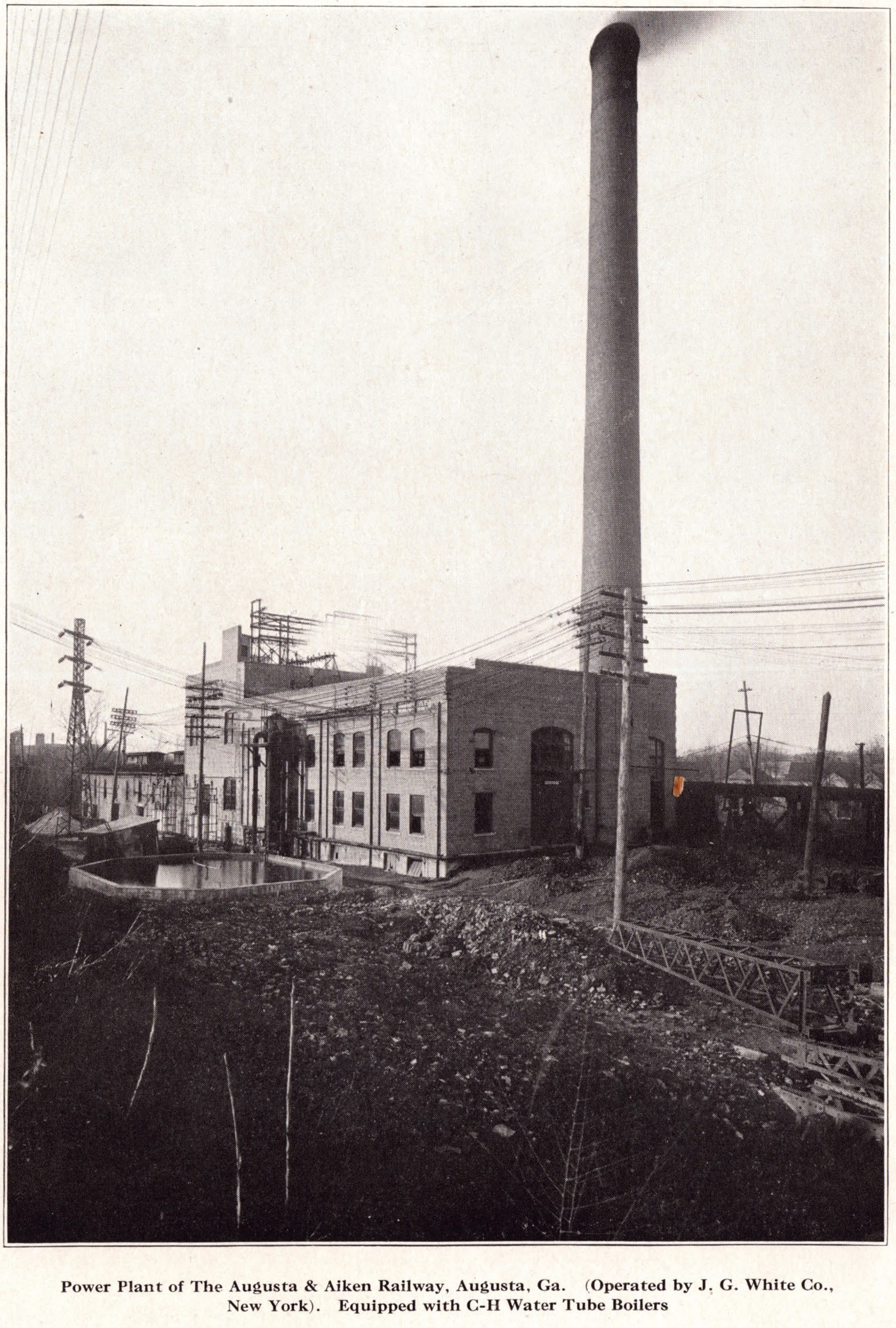
Each boiler is fitted with a winged pattern steel dry pipe, the design of the dry pipe being clearly shown in accompanying illustration.

Boilers of the Longitudinal Drum Type are suspended at the front end with overhead girders and side columns. Loops extend around the drum and are attached to the overhead girders. At the rear end the boiler is supported by heavy columns with expansion plates and rollers. Thus the boiler is suspended entirely free from the brick work and can expand or contract in any direction without interfering with the setting.

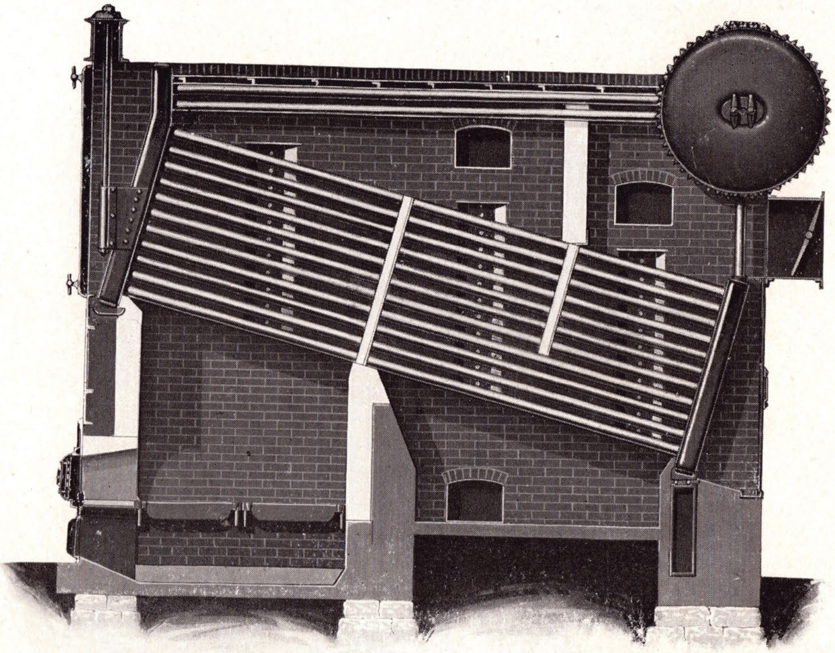
The boiler front is made of steel and cast iron and is attached to the front boiler supports and is arranged so that the lower half can be removed and any type of stoker installed if desired. The fire front section is composed of cast iron panels carrying the fire and ash doors. Blank spacing panels are used to fill in between the panels carrying the fire and ash doors. The fire doors are hung on a bevel on an independent frame, are of massive design and provided with door registers and perforated liner plates. The door handles are hollow. Standard doors are furnished with fire tile door jambs. Special fire doors have cast iron door arches. Standard dead plates are arranged for fire brick lining. For closing in between side walls and drums tee bars are provided. Cleaning doors for the sides and rear walls of setting are of heavy cast iron with liner plates. Doors have tightly fitting latches and the joints are practically air tight. Buck stays for the sides and rear walls are of heavy pressed steel.

The rear header is provided with a hinged steel door on a structural frame. This door protects the rear header from losses due to radiation. Side dusting doors are provided and are of such pattern that they close semi-automatically. Cast iron lintels are provided for the wall at top and bottom of the dusting door openings.

When so required, boiler fronts will be provided with firing and ash cleaning doors of the inward-opening type. Such doors are provided with counter-weights and are of the design as shown on page 19.



Power Plant of The Augusta & Aiken Railway, Augusta, Ga. (Operated by J. G. White Co., New York). Equipped with C-H Water Tube Boilers



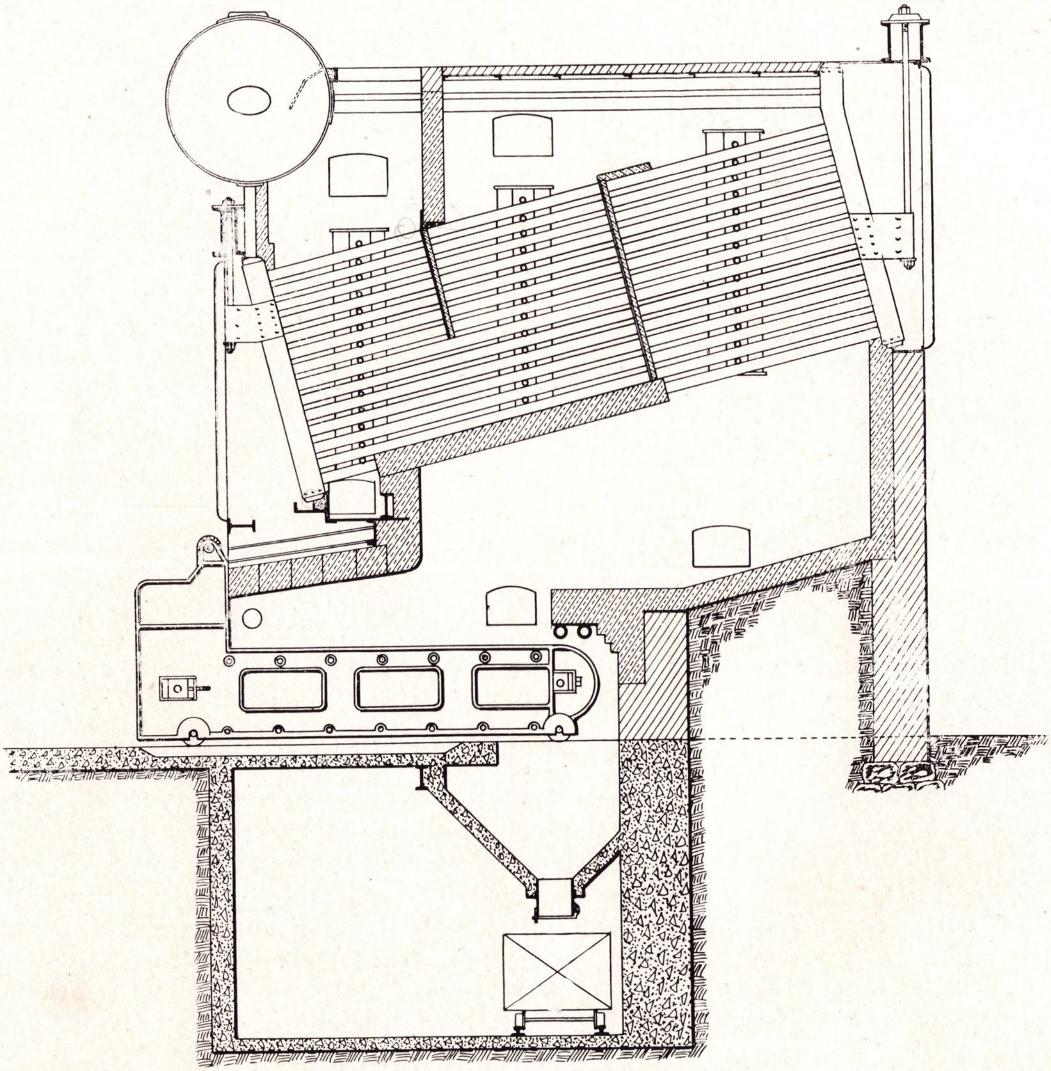
C-H Cross Drum Water Tube Boiler Type R2. Sectional View Through Setting

Cross Drum Type

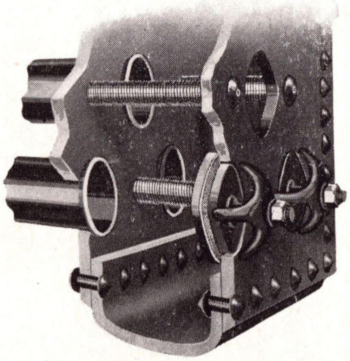
THE drum of this type of boiler instead of being placed longitudinally is placed transversely across the boiler at the rear end and is connected to the headers by means of circulating tubes expanded into drilled tube holes in the headers and drums. All drums on this type of boiler are manufactured in accordance with the same methods used on the longitudinal type of boiler. The longitudinal seams are the butt joint type with inside and outside covering straps. The headers are of practically the same construction as the longitudinal type of boiler. Cross Drum Boilers at the rear are supported by the back header resting on cast iron foundation plates with expansion rollers and on boilers set high above the grates, columns are provided. At the front, the boiler is supported by overhead girders and side columns. Suspension bolts extend from steel lugs on the front header to the overhead girders. The whole system of suspension is such that it allows for the expansion and contraction without straining the boiler or brick work. Boiler fronts of the Cross Drum Boiler are practically the same as those of the longitudinal type. The fixtures such as side dusting doors, baffles, lintels, cleaning doors and frames, etc., correspond with those furnished on the longitudinal drum boiler.

FITTINGS AND FIXTURES

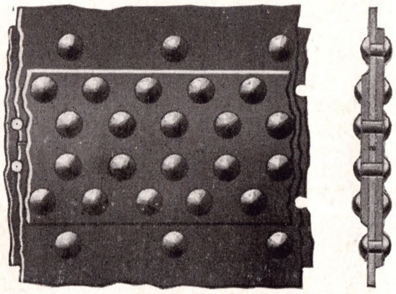
Either type of boiler is provided with the following fittings which are standard equipment: The necessary nickel seated pop safety valves; large diameter water column; brass rim steam gauge; brass high pressure globe and check valves for feed line; heavy blow-off cocks; three gauge cocks, weighted pattern with chains; water gauge and glass quick-closing type; standard equipment of buck stays and tie rods; set of grate bars and bearers; suspension for front end of boiler; fire front with fire and ash doors; front tube doors; rear tube doors; closing in bars; dead plates; baffle tile; baffle tile retainers; side cleaning doors; set of fire tools; and soot blowing lance with valve.



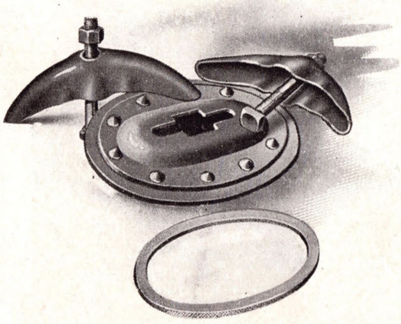
Cross Drum Boiler Arranged for Chain Grate Stoker, Combination Baffle with Tube Inclination Forward



Section Through Steel Header



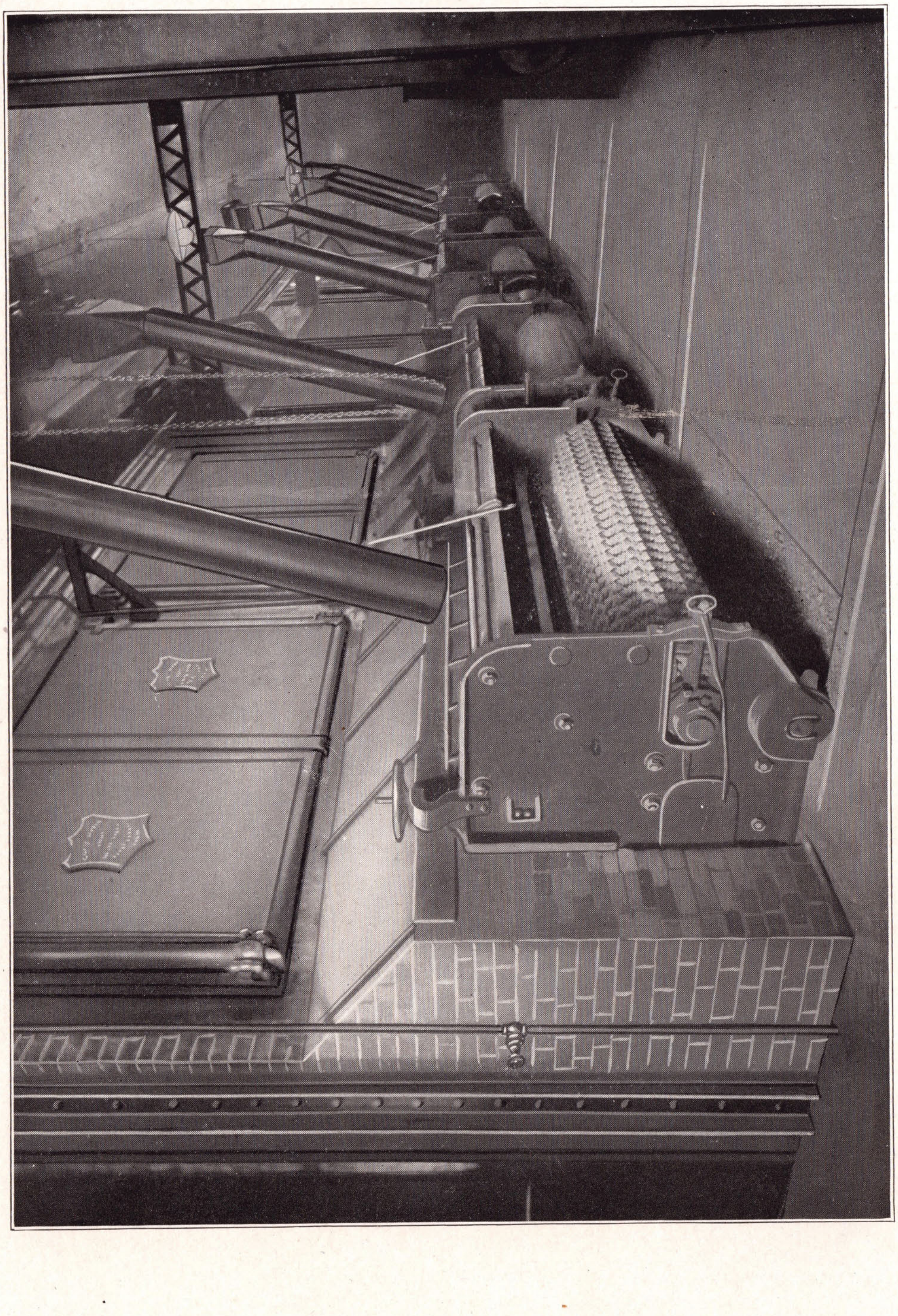
Rivet Joint—Longitudinal Seams of Drum



Pressed Steel Manhole Plate and Arches

HEADERS

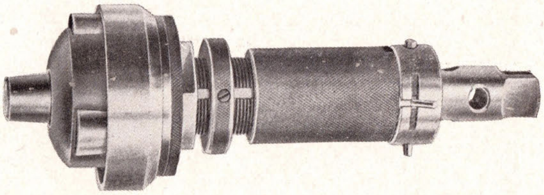
Headers are constructed entirely of steel. Instead of being flanged over on the edge, the headers are closed with a special wrapper sheet. This construction eliminates the necessity of flange work on the header and tube sheet. Flanging the edges of the tube and handhole sheets sets up a strain in the metal and is not the best practice. Handhole openings are oval so the handhole plates can be removed through their own openings. Handhole plates and arches are of forged steel. Bearing surface of handhole plates are machined off, handhole plates are a neat fit and the construction is such that it is practically impossible to blow a gasket. Cast iron handhole plates and arches are not considered safe construction. If so ordered boilers will be fitted with Key patented handhole plugs eliminating gaskets, making a metal to metal joint. Stay bolts used for stay bolting headers are of special quality refined iron or steel and are solid with holes drilled in each end to a depth of 1½″. This stay bolt has all the qualities of the hollow stay bolt but the continuous hole is eliminated. These holes are generally plugged up when hollow stay bolts are used, but the plugs are never in place, in consequence there is a large amount of excess air entering the interior of the boiler setting, increasing the amount of fuel required to operate the boiler. The C-H header construction is the strongest header possible to build. There are no uncertainties—no cast iron to crack. Steel castings are eliminated. It is found that steel castings are very little, if any better, than cast iron, as they are usually full of blow holes, although their surface might indicate sound castings. In either the cast iron or cast steel header, there is a danger of the cores shifting in the process of casting. Should this happen, the header would be thin on one side and thick on the opposite side. In the forged steel header, the metal is stretched and tortured by the continuous working and reheating of the metal and there is a danger of thinning the metal to the extent that the forging is unsafe. Although the forging may be tested hydrostatically to a very high pressure and does not fail, there is a danger of the elastic limit of the metal being exceeded in making this test at the points where the thinning process has been the greatest. Although there is no failure when the elastic limit is exceeded, there is a permanent set or strain in the metal and this will develop a weakness in service.



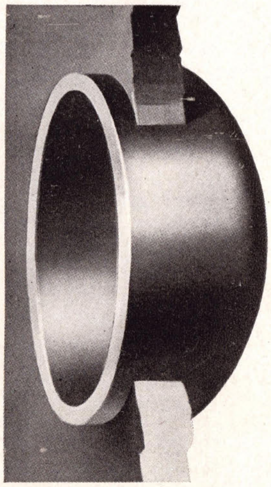
Boiler Room of City of Logansport, Ind., Equipped with C-H Water Tube Boilers, Chain Grates, and Foster Super-Heaters

KEY SAFETY HANDHOLE CAP

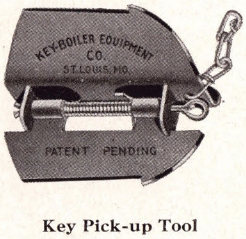
The Key Safety Handhole Cap requires no gaskets and will be furnished with C-H Water Tube Boilers providing it is understood and noted in contract when the order is placed that this type of handhole cap or plug is wanted. Key handhole caps have been tested in especially designed apparatuses to 3,000 lbs. pressure per square inch without evidence of leakage or weakness. The Key cap is introduced into the water legs through oval or master holes, there being a very small number of these oval holes in the boiler. These are provided with the regular oval plate, gasket, bolt and arch. It is very easy to pass the Key cap through the water leg by hand or the Key Patented Pick-up Tool, which is furnished with each boiler, may be used. The Caps are drawn into place in the handhole opening by means of a Key Roller Tool, which pulls the cap tight into place. The caps may be used over and over again. The Key cap complies with the A. S. M. E. Boiler Code requirements and has been approved for use by the United States Steamboat Inspection Service, the Hartford Steam Boiler Inspection and Insurance Company, the Fidelity and Casualty Company, the Travelers Insurance Company and by all other boiler insurance companies.



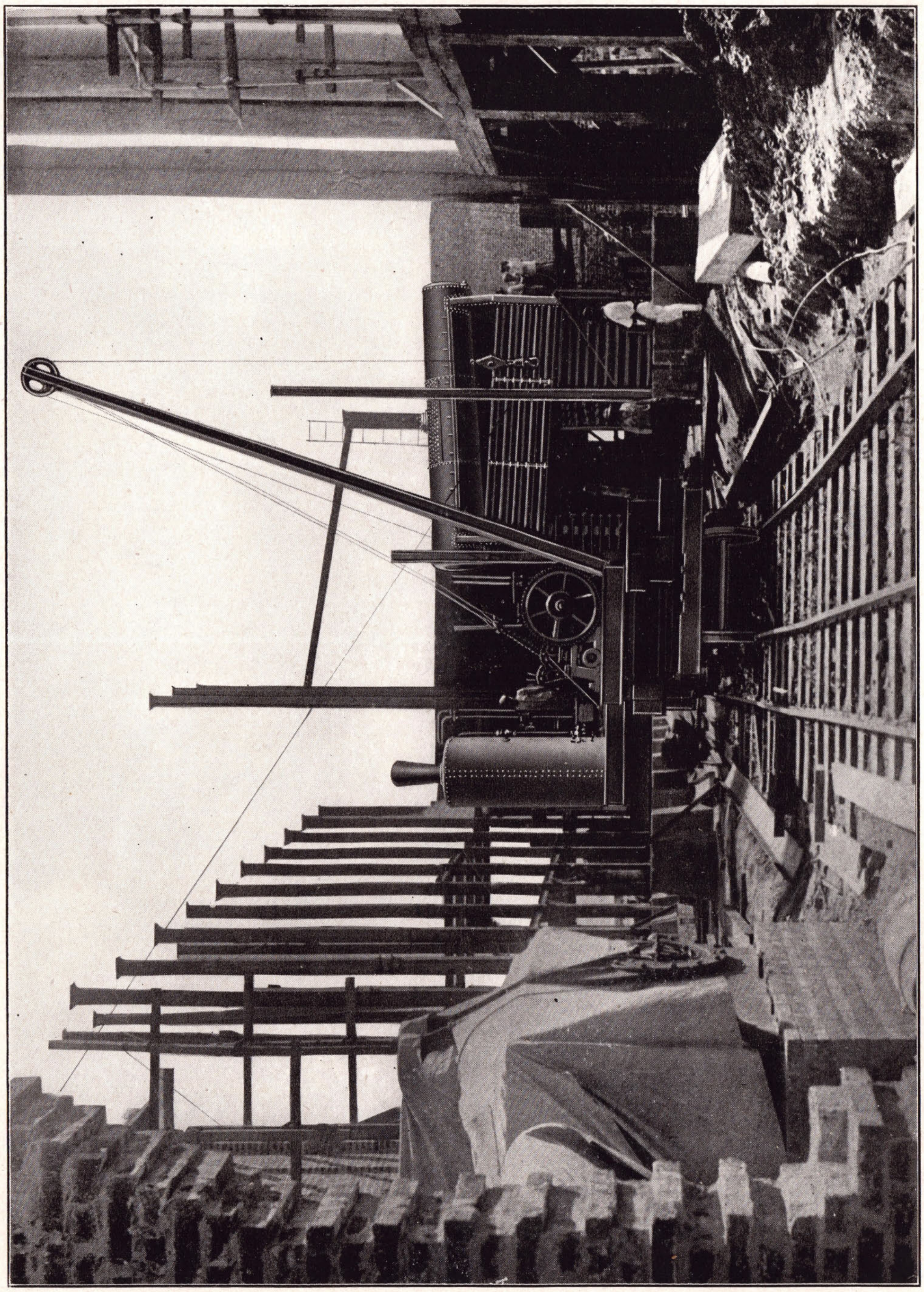
Key Roller Tool



Key Handhole Plug in Place

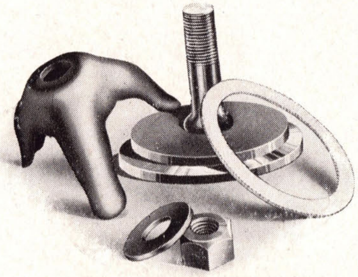


Key Pick-up Tool

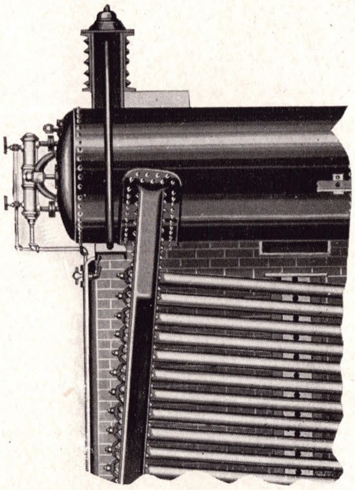


Erection of Five 300-H.P. C-H Horizontal Water Tube Boilers, International Products Company, Puerto Pinasco, Paraguay, S. A.

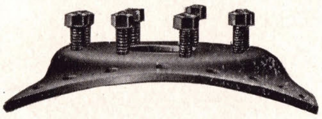
Advantages of the C-H Horizontal Water Tube Boiler



C-H Forged Handhole Plate and Arch



Method of Supporting Boiler at Front End



Forged Nozzle Pad

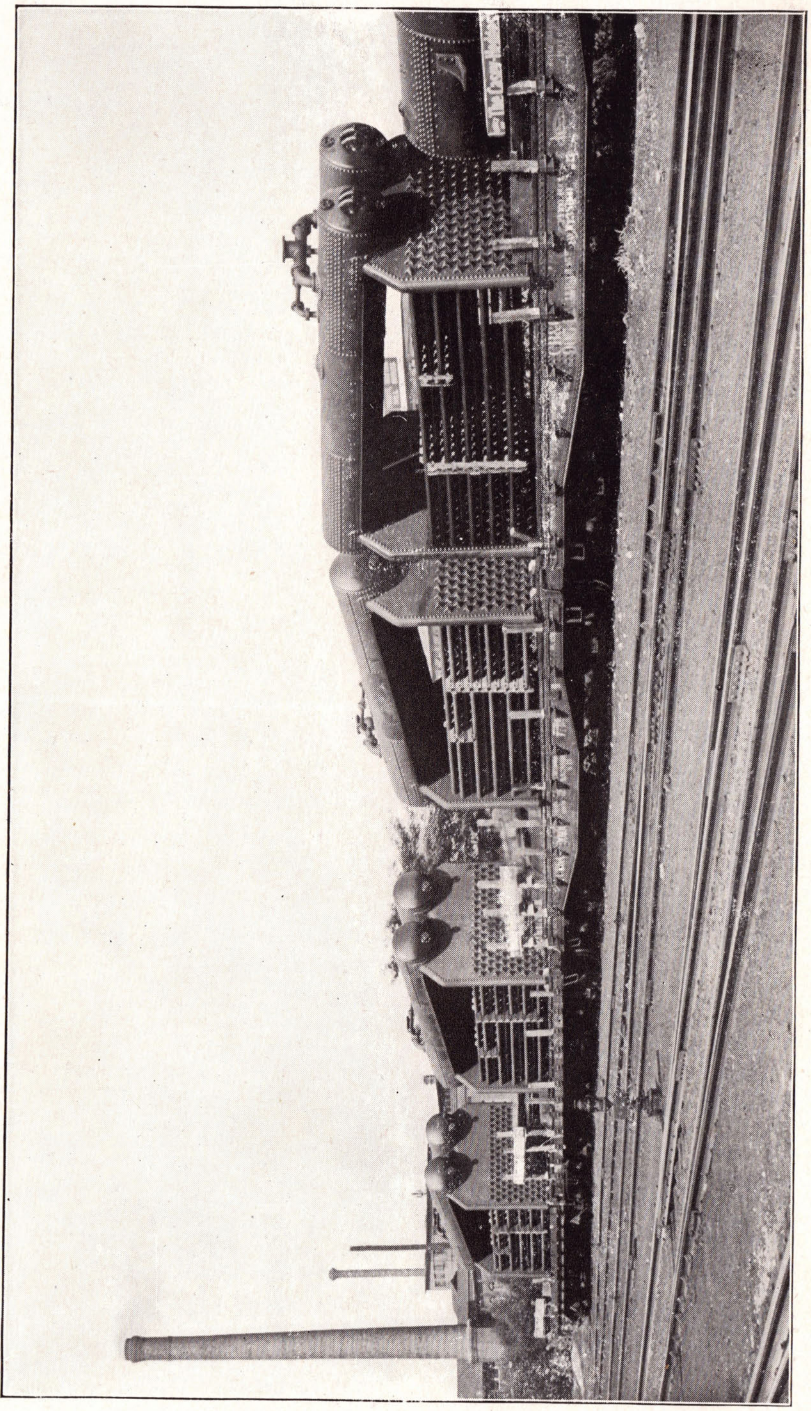
THE advantages of the C-H Horizontal Water Tube Boiler over other types are briefly laid before the prospective purchaser in the following:

CONSTRUCTION OF STEEL

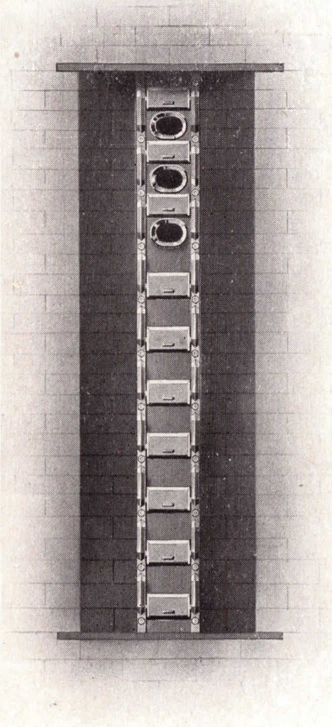
The boiler pressure parts are built entirely of wrought steel. Not even the handhole arches are of cast iron. Cast iron headers for Water Tube Boilers as well as handhole plates, cross boxes, etc., have proven to be dangerous construction. The insurance companies' records showing list of boiler failures will bear out this statement.

ACCESSIBILITY

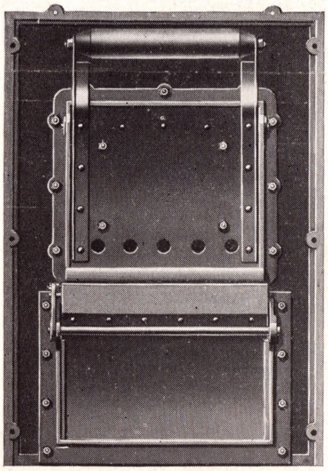
The boiler is accessible for cleaning in all its parts. Scale or mud may be completely removed from the interior of the drum or tubes. Handholes give access to each tube at both ends and by using a light at one end of the tube and looking through the other end, one can readily ascertain if the interior is clean and free from scale. Tubes are easily cleaned from the front end outside with a hydraulic turbine tube cleaner, it being only necessary to remove the caps on the front end and those on the bottom row on the rear end so as to drain the boiler. Any accumulation in the headers can also be removed through the handholes. The interior of the steam drum is accessible through the manholes in the drum heads and all parts of same can be cleaned and inspected. Exterior heating surface of the boiler can be thoroughly cleaned by inserting a steam lance through the side dusting doors. Mechanical soot blowers can be applied without alteration of the boiler. The interior of the setting of the boiler is accessible by means of large cleaning doors, which are provided with heavy latches that close the doors practically air tight.



Shipment of C-H Patented Water Tube Boilers for Central "America," Oriente Province, Cuba



Self-closing Dusting Doors for Side Walls



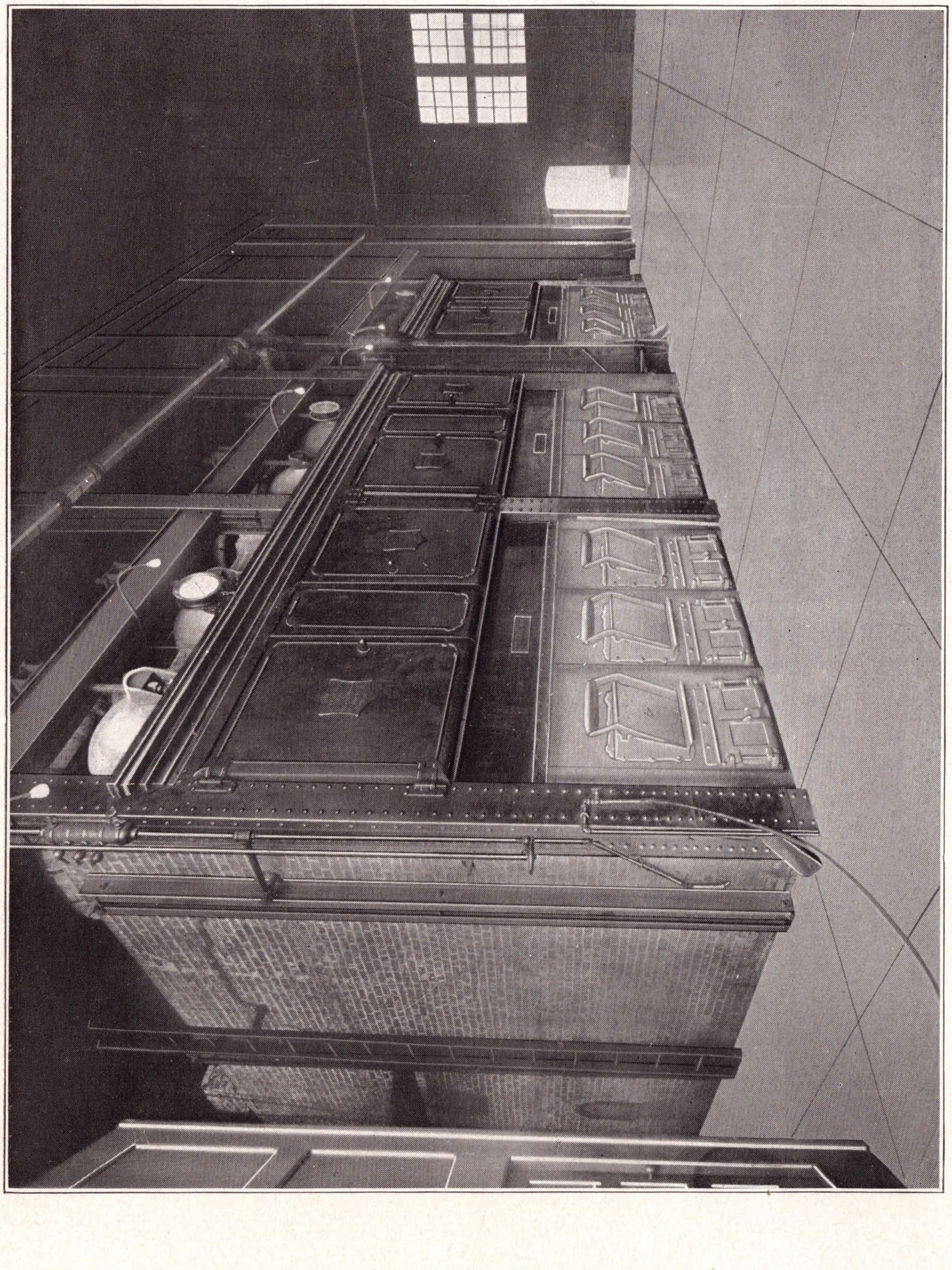
Inside Opening Fire and Ash Doors

REPAIRS

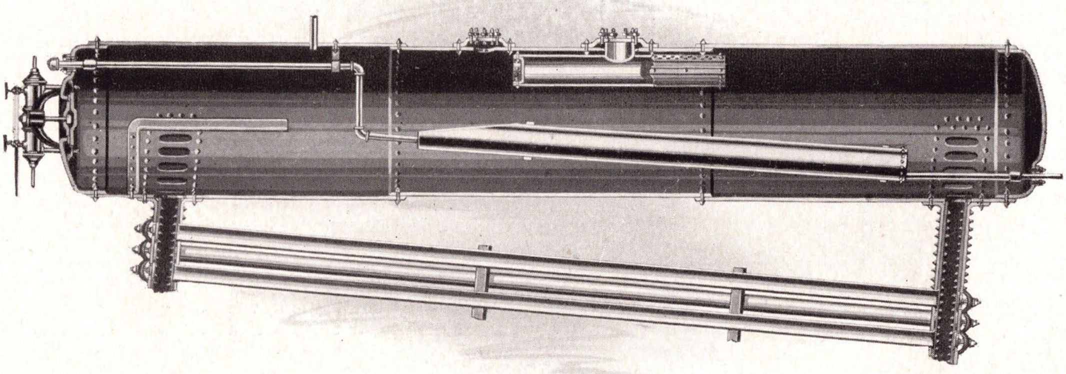
Repairs on C-H Horizontal Water Tube Boilers are of minor consideration, it being seldom necessary to make a repair. Repairs ordinarily consist of renewing one or two tubes on the lower row. The tubes being of a standard size and perfectly straight, are carried in stock by all jobbers and warehouses and can be purchased at a nominal figure. These tubes can be easily inserted in the boiler and expanded into place in the tube sheets by a stationary engineer of ordinary ability. There are no large shells or boiler parts exposed to the direct action of the heat. A C-H Horizontal Water Tube Boiler properly taken care of should be capable of carrying the same pressure as that for which originally built over a period of many years.

CIRCULATION

Circulation in the C-H Water Tube Boiler is positive, continuous and in one direction. This important feature is never challenged by manufacturers of other types. The headers are of ample size to permit unrestricted circulation but are not large enough to cause counter-circulation. The circulation or flow of steam and water is upward through the tubes from the rear to the front header, then through the front header into the drum where the steam is liberated. The water then returns back to the rear header downward, then through the tubes, forming a continuous unobstructed circuit through the boiler. The splendid circulation in a C-H Water Tube Boiler permits overloads to be carried with perfect safety, insures a clean boiler, a uniform temperature throughout, equal expansion in all parts and permits steam to be raised in the shortest possible time.



Three 400 H.P. C-H Water Tube Boilers Furnised J. G. White Co., for Augusta, Ga.

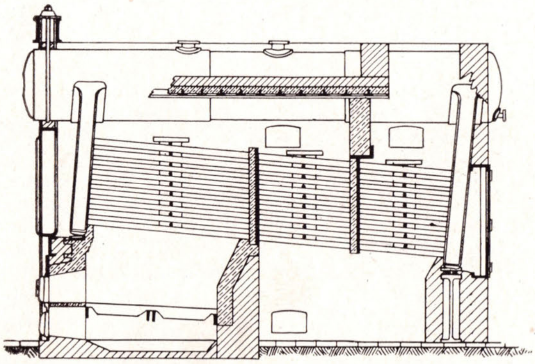


Section Thru Drum Showing Dry Pipe, Mud Drum and Baffle Plate

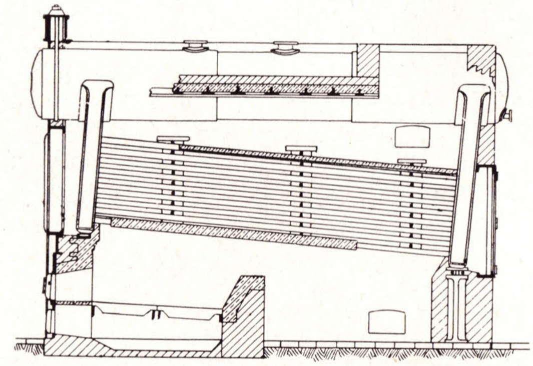
CAPACITY

Design of the C-H Horizontal Water Tube Boiler is such that overloads may be continuously carried. It is not infrequent to see these boilers operated at 200% rating continuously. (Of course, when boilers are operated beyond their rating, it is absolutely necessary to keep both their exterior and interior clean). Peak loads are carried at periods to the extent of 300% rated capacity. Our type 2-R Cross Drum Boiler designed in large units is peculiarly adapted to peak loads. The perfect circulation in the C-H Horizontal Water Tube Boiler is one of its most important features in handling overloads. Wet steam is always the result of improper circulation. Some manufacturers contend that large liberating surfaces and large drums are requisite for dry steam and neglect the important detail of circulation in their design. Our Cross Drum type of boiler does not have as much liberating surface as our longitudinal type and it has been erroneously stated that the Cross Drum type of boiler does not produce dry steam. In marine practice, modified types of Cross Drum Boilers are universally used. The drums are very small and the boilers are usually operated on a basis of five square feet of heating surface per horsepower and they deliver dry steam with less than one-half of 1% moisture. Some manufacturers try to convince the prospective buyer their boiler will accomplish results beyond what are theoretically possible, but they are not in position to back up their arguments with facts substantiated by those standing high in the engineering profession. We do not pretend in any way to sell freak construction nor do we say our boiler will do the impossible.

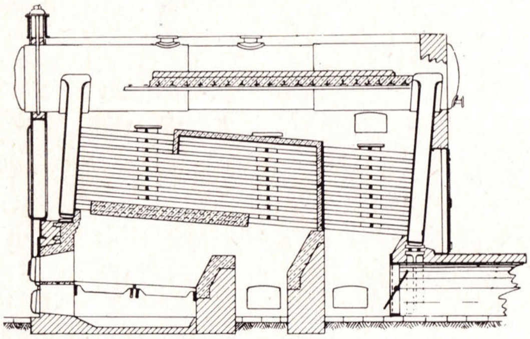
Showing Methods of Baffling The C-H Standard Horizontal Water Tube Boiler



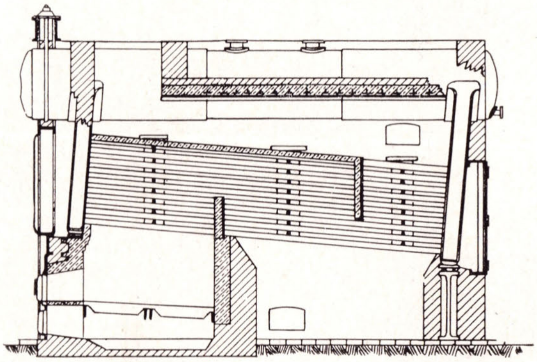
No. 1—Standard Baffling. Three vertical passes. Take off at rear.



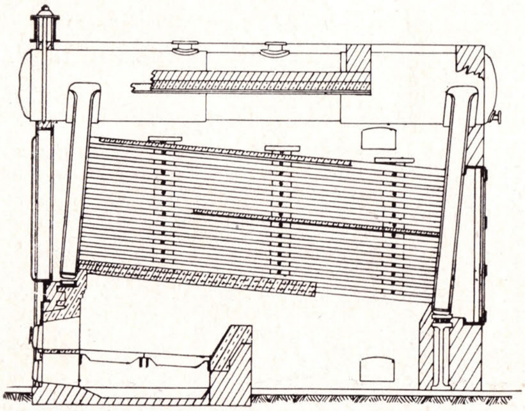
No. 2—Horizontal pass Dutch Oven effect in furnace by encasing lower tubes with tile. Take off at rear.



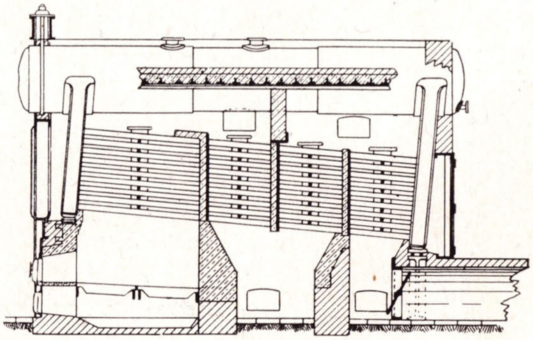
No. 3—Combination horizontal and vertical pass. Take off at rear at bottom.



No. 4—Three pass. Take off at front at top.



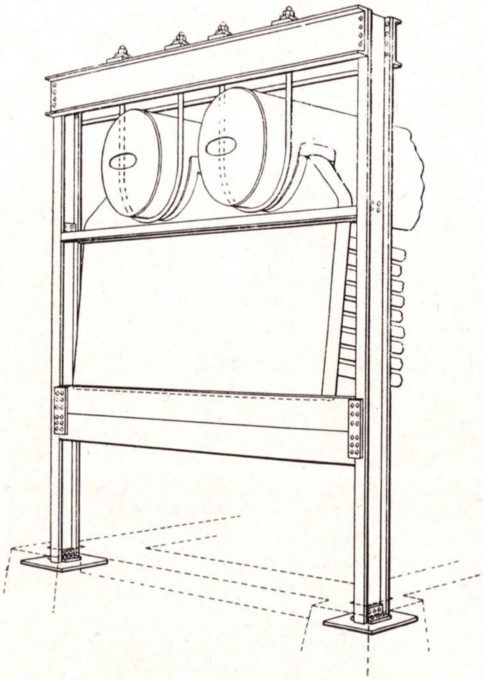
No. 5—Double horizontal baffle used on boilers fourteen tubes high. Take off at rear.



No. 6—Four vertical passes. Take off at bottom at rear.

SETTING OF BOILER AND SPACE OCCUPIED

The C-H Horizontal Water Tube Boiler presents an unequalled combination in Water Tube Boiler design, of compactness, accessibility, strength, and efficiency. It is possible to design a boiler that would occupy less space, but in so doing some of the necessary details in the construction of a successful, well-proportioned boiler are eliminated, such as grate surface out of proportion to heating surface, boiler inaccessible for cleaning, expensive repairs required at frequent intervals, lack of space for combustion of fuel, unsafe construction, etc. As compared with other standard types of boilers, our Cross Drum type occupies less floor space and can be set with less head-room than any other successful type, and is especially adapted to installations where headroom is limited. We know of no other type of boiler that requires less brick work to set a given horsepower and at the same time the wall thicknesses are ample to prevent any radiation from the interior. The boiler being supported entirely free from the brick work eliminates any danger from cracking of the side walls due to expansion or contraction. No weight of the boiler being carried on the walls, the side walls are of a minimum thickness. Expensive foundations are not required. On some other types of Water Tube Boilers the foundation cost alone is as much as the brick work and foundations on the C-H Boiler. The furnace itself is within the boiler and by using the combination type of baffle, a Dutch Oven furnace is made within the boiler setting; such furnace construction being necessary to obtain the best results on some grades of high volatile bituminous coal when fired by hand. Such fuels as bagasse, tan bark, etc., require special furnace construction, which is easily applied to the C-H Horizontal Water Tube Boiler and our Engineering Department is capable of designing furnaces for any kind of refuse fuel. Designs will be furnished on application, showing the furnace construction for either sawdust and shavings, cord wood, spent tan bark, wood chips, refuse from tanneries and turpentine extract plants, crude oil; anthracite and bituminous coal; natural gas, blast furnace gas, by-products coke oven gas, waste heat from cement plants.

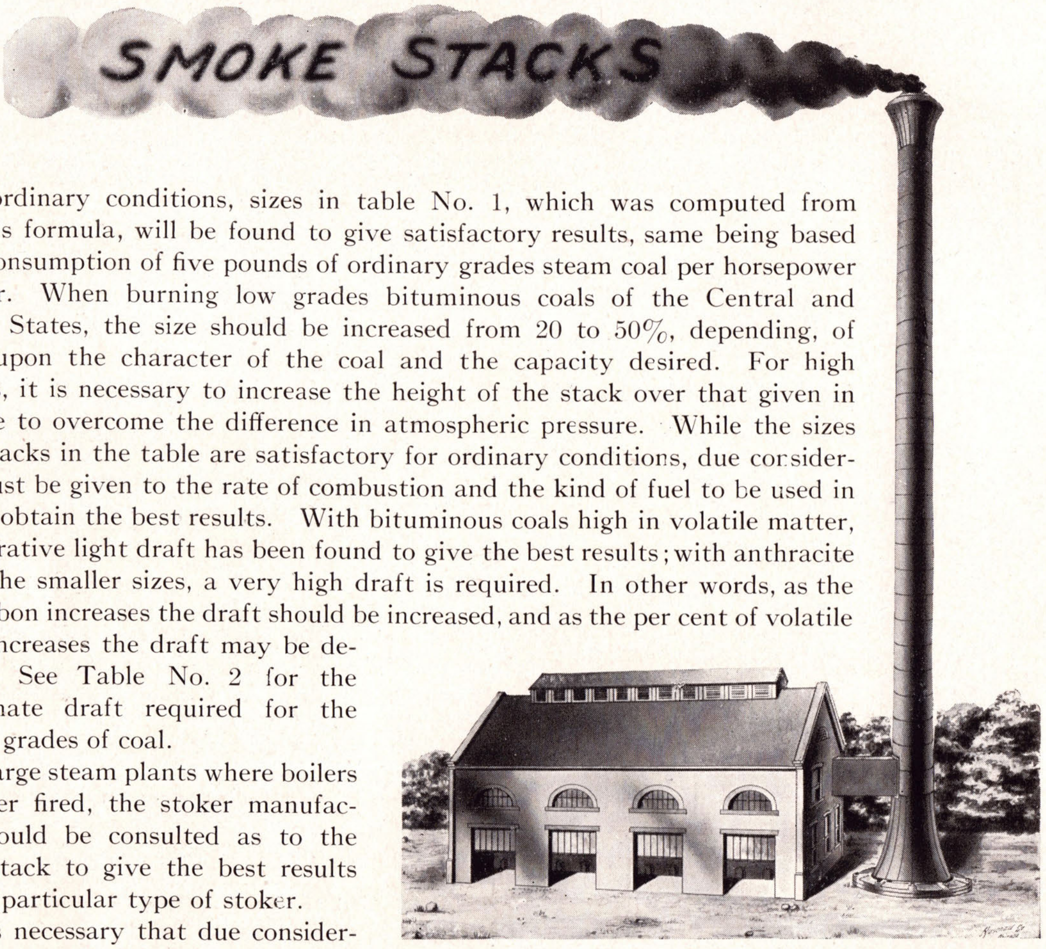


Front End Boiler Supports

BAFFLING

The C-H Horizontal Water Tube Boiler is designed so that any type of baffling that can be applied to a Horizontal Water Tube Boiler may be used. On page 22 a number of illustrations are shown which illustrate the various types of baffling that we are in position to furnish. Some manufacturers insist on furnishing only one type of baffling, although the engineering profession is well aware of the fact that it is necessary to alter the type of baffling to get the best results for different conditions and classes of fuel. Sometimes it is necessary to take the gases from the boiler through an underground smoke flue at the rear instead of through the usual steel breeching at the back end of the boiler. Often times there are building difficulties in the way and it is necessary to place the breeching at the top and at the front end of the boiler. We are prepared to arrange our baffling so that we can take care of any special requirements of the purchaser.

SMOKE STACKS



FOR ordinary conditions, sizes in table No. 1, which was computed from Kent's formula, will be found to give satisfactory results, same being based on the consumption of five pounds of ordinary grades steam coal per horsepower per hour. When burning low grades bituminous coals of the Central and Western States, the size should be increased from 20 to 50%, depending, of course, upon the character of the coal and the capacity desired. For high altitudes, it is necessary to increase the height of the stack over that given in the table to overcome the difference in atmospheric pressure. While the sizes of the stacks in the table are satisfactory for ordinary conditions, due consideration must be given to the rate of combustion and the kind of fuel to be used in order to obtain the best results. With bituminous coals high in volatile matter, a comparative light draft has been found to give the best results; with anthracite coal of the smaller sizes, a very high draft is required. In other words, as the fixed carbon increases the draft should be increased, and as the per cent of volatile matter increases the draft may be decreased. See Table No. 2 for the approximate draft required for the different grades of coal.

In large steam plants where boilers are stoker fired, the stoker manufacturer should be consulted as to the size of stack to give the best results with his particular type of stoker.

It is necessary that due consideration be given to draft losses. The kind of fuel and load conditions will determine the amount of draft required over the grates. The draft loss through the boiler depends entirely upon the method of baffling and the area of the passages through which the gas must pass. However, it is safe to figure the draft loss through the boiler to be approximately 0.4″. The loss in draft through the breeching will amount to 0.01″. If the breeching is long or if there are any sharp turns, add from 0.05″ to 0.10″. The draft losses through the boiler and breeching should be totaled to give the theoretical draft required to which 25% should be added for actual operating conditions. An example is as follows:

A boiler plant of 1,000 horsepower requiring ½″ draft over the grates, figuring 0.4″ for boiler loss and 0.15″ for loss through breeching, equals 1.05″ theoretical draft required at base of stack; adding 25% for actual operating conditions, equals a total of 1.31″ of actual draft required at base of stack. The height of the stack can be approximated by dividing the draft required in inches by .0071 and in the above 1,000 horsepower plant, it will be found that by dividing 1.31 by .0071 a stack approximately 185′ is required. Refer to table of stack diameters No. 1. It will be found that in the instance of the above plant a 72″ diameter stack is sufficient.

Supplementing table No. 2, which gives the approximate draft required for the different grades of coal, table No. 3 approximate draft power required for the different grades of fuel, will be found very useful.

TABLE No. 1

Size of Chimneys or Stacks for Steam Boilers

(WM. KENT)

Diameter, Inches	Area (a) Sq. Ft.	Effective Area E=A—0.6 A Square Ft.	HEIGHT OF CHIMNEY														Equivalent Sq. Chimney Side of Sq. E+4 Inches
			50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.	225 ft.	250 ft.	300 ft.	
			Commercial Horsepower of Boiler														
18	1.77	.97	23	25	27	29											16
21	2.41	1.47	35	38	41	44											19
24	3.14	2.08	49	54	58	62	66										22
27	3.98	2.78	65	72	78	83	88										24
30	4.91	3.58	84	92	100	107	113	119									27
33	5.94	4.48		115	125	133	141	149	156								30
36	7.07	5.47		141	152	163	173	182	191	201							32
39	8.30	6.57			183	196	208	219	229	245							35
42	9.62	7.76			216	231	245	258	271	289	316						38
48	12.57	10.44				311	330	348	365	389	426						43
54	15.90	13.51					427	449	472	503	551	595					48
60	19.64	16.98					536	565	593	632	692	748					54
66	23.76	20.83						694	728	776	849	918	981				59
72	28.27	25.08						835	876	934	1,023	1,105	1,181	1,253			64
78	33.18	29.73							1,038	1,107	1,212	1,310	1,400	1,485	1,565		70
84	38.48	34.76							1,214	1,294	1,418	1,531	1,637	1,736	1,830	2,005	75
90	44.18	40.19								1,496	1,639	1,770	1,893	2,008	2,116	2,318	80
96	50.27	46.01								1,712	1,876	2,027	2,167	2,298	2,423	2,654	86
102	56.75	52.23								1,944	2,130	2,300	2,459	2,609	2,750	3,012	91
108	63.62	58.83								2,090	2,399	2,592	2,771	2,939	3,098	3,393	96
114	70.88	65.83									2,685	2,900	3,100	3,288	3,466	3,797	101
120	78.54	73.22									2,986	3,226	3,448	3,657	3,855	4,223	107
132	95.03	89.18									3,637	3,929	4,200	4,455	4,696	5,144	117
144	113.10	106.72									4,352	4,701	5,026	5,331	5,618	6,155	128

For a rough approximation of the pounds of coal burned per hour for any given size of chimney, multiply the figures in the table by 5.

TABLE No. 2

Draft Required at Grates in Inches for Different Grades of Coal

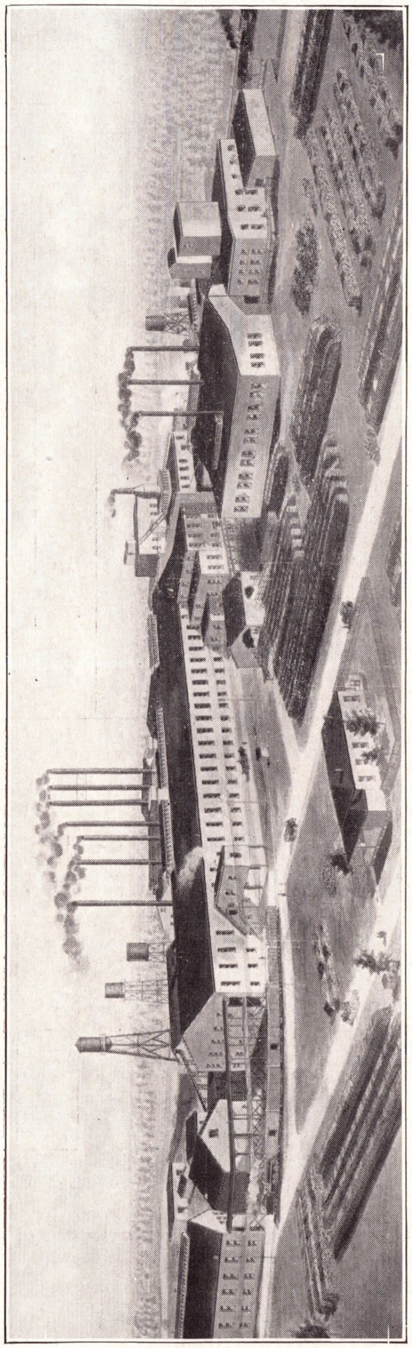
Table gives approximate number of pounds that can be burned per square foot of grate surface of different drafts

Draft required in inches in Furnace	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4
Ill., West. Ky., Kas., Ind., Bituminous	11	20	26	34	42									
Penna., Tenn., Ala., Eastern Ky., Bituminous Coal	10	16	23	28	34	39	42							
Penna., Va., W. Va. Semi-Bituminous Coal	9	16	22	27	32	36	40	43						
Anthracite Pea Coal	6	10	14	17	20	23	25	27	29	31	33	34	36	37
Anthracite Buckwheat No. 1			11	15	16	19	20	21	22	24	25	26	27	28
Anthracite Buckwheat No. 2				11	13	15	17	18	19	21	22	22½	23	24½
Anthracite Buckwheat No. 3					12	13	14	16	17	18	19	20	21	22

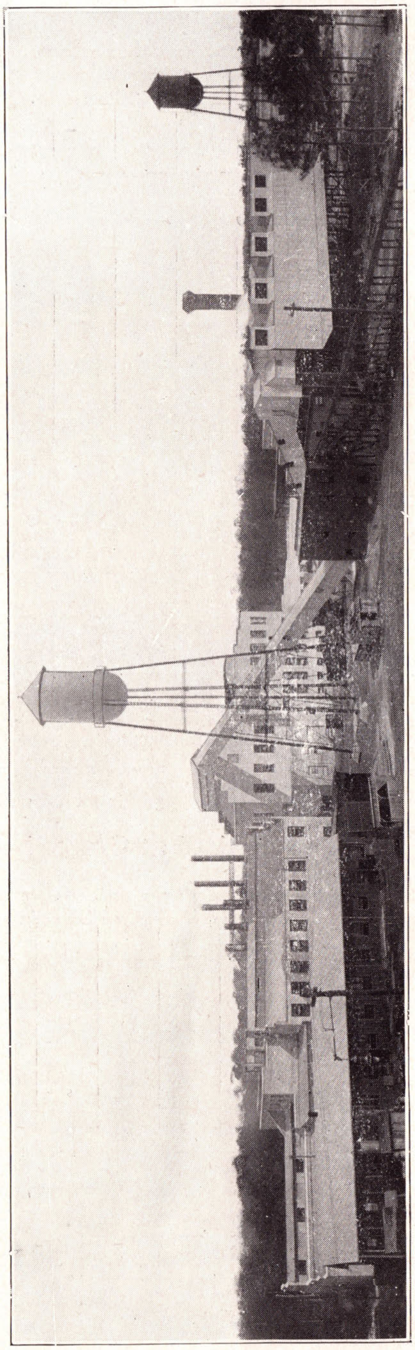
TABLE No. 3

DRAFT REQUIRED IN FURNACE IN INCHES FOR THE EFFICIENT COMBUSTION OF VARIOUS FUELS

Straw	0.2
Wood	0.3
Sawdust	0.4
Bagasse	0.4
Steam Coal	0.5 to 0.8
Slack	0.7 to 1.2
Breeze and Slack	0.7 to 1.2
Anthracite Pea	1.0 to 1.5
Anthracite Buckwheat	1.2 to 1.7



Yellow Pine Paper Mills, Orange, Texas, Equipped with C-H Water Tube Boilers



Southern Paper Co., Moss Point, Miss., Equipped with C-H Water Tube Boilers

Smoke Breechings

SMOKE breechings are usually made slightly larger than the cross sectional area of the stack—preferably 20%. A safe rule is to figure not less than 500 sq. in. of cross sectional area for each 100 horsepower. In designing the breeching, maintain the full area required for the entire plant over the boiler nearest the stack and gradually decrease the area as it extends to the boiler farthest away from the stack. Be sure to maintain the correct area over each boiler as the breeching is reduced. Always bear in mind, regardless of size of the stack, that it is necessary to maintain a breeching area of the above proportions. A considerable difference will be noticed between the breeching area, using the above proportions on very tall stacks in which the diameter has been decreased due to the increased height.

STACKS FOR OIL BURNING

For burning oil, a large stack is not required, due to the decreased draft required in the furnace to maintain combustion, liquid being atomized into the furnace and this process automatically makes its own air mixture, there being no fuel bed to draw the air through.

It is usual to limit the height of a stack on very large installations ranging from 4,000 to 6,000 horsepower to 150′. For installations between 2,000 and 4,000 horsepower to 125′. For installations 1,000 to 2,000 horsepower to 100′. For installations less than 1,000 horsepower, stack heights usually range from 60 to 80′. In selecting a stack for burning oil, size may be approximated by the following method:

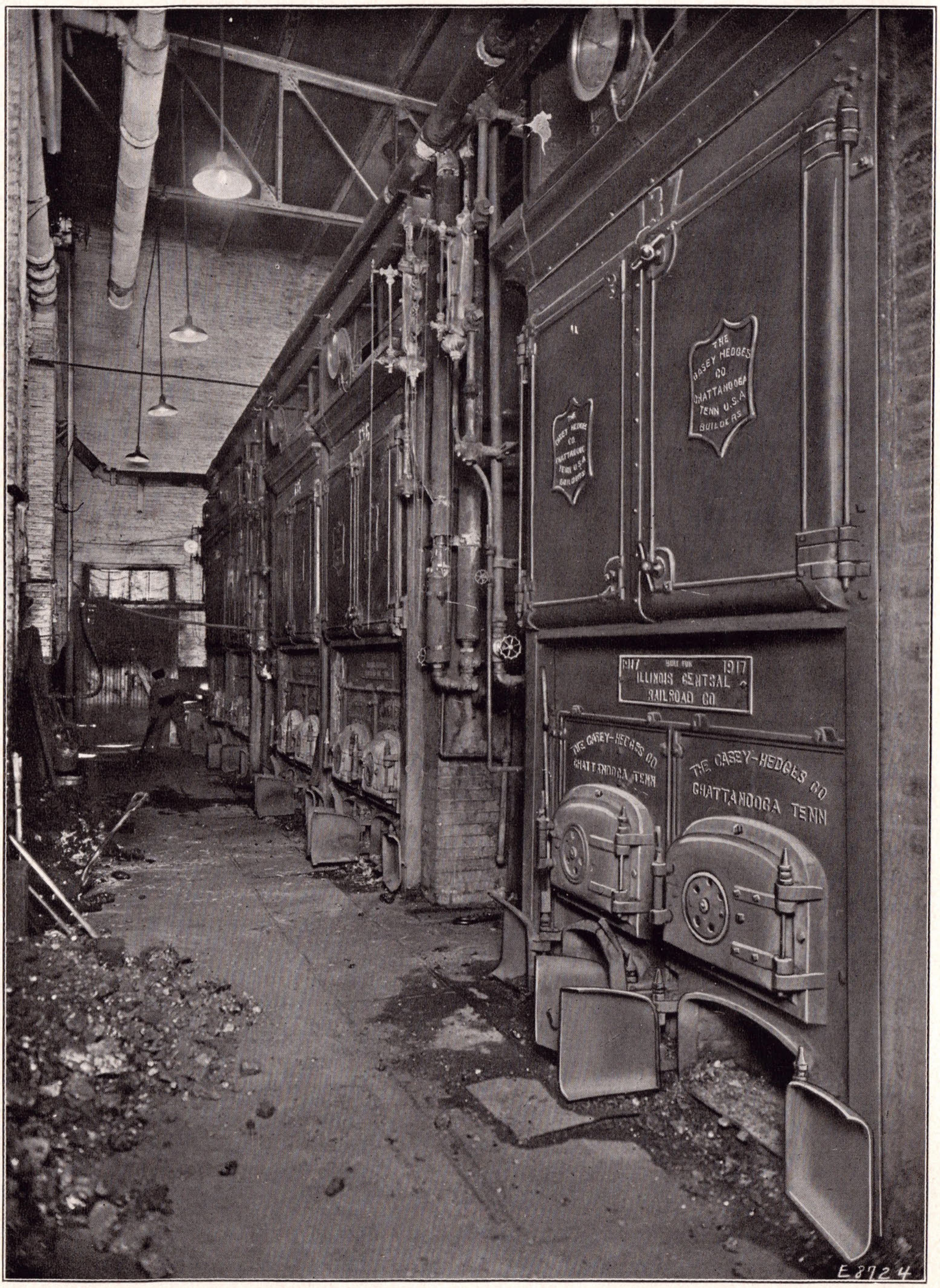
Multiply the normal horsepower of the boiler plant by .6, then from Kent's table, using the result given, select a stack within the height ranges as noted above. In other words, a plant of 3,000 horsepower, oil fired, would require a stack 125′ high. Multiplying the 3,000 horsepower by .6, gives the equivalent of 1,800 horsepower of a coal fired stack. It will be found that a 96″ x 125′ stack is approximately what is desired.

STACKS FOR BURNING WOOD, SAWDUST AND BAGASSE

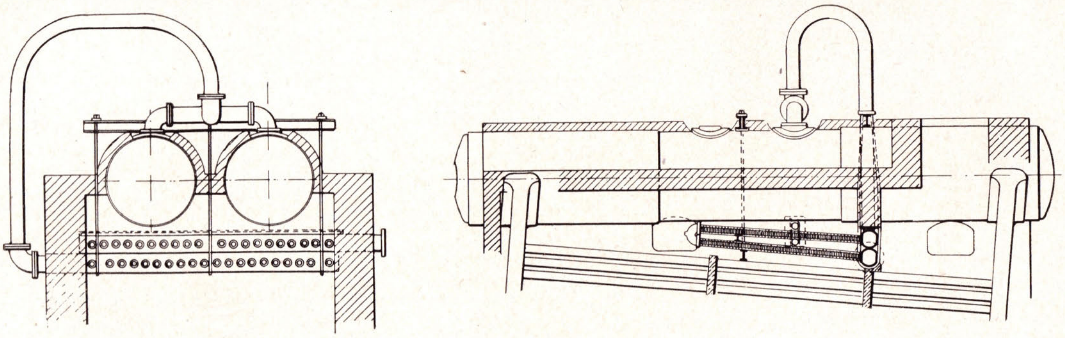
For burning wood, sawdust and bagasse. it is found that stack sizes in Kent's table are very satisfactory.

STACKS FOR BURNING WASTE HEAT FROM BLAST FURNACES

The draft for blast furnace gas should be about .8 of an inch at the boiler outlet. A stack to produce this draft should be about 125 to 140 feet in height and it is not advisable to exceed these heights. The diameter of the stack may be the same as that for burning coal.


THE CASEY HEDGES CO CHATTANOOGA TENN U.S.A. BUILDERS
1917 ILLINOIS CENTRAL RAILROAD CO. 1917
THE CASEY-HEDGES CO CHATTANOOGA TENN
THE CASEY-HEDGES CO CHATTANOOGA TENN
E8724

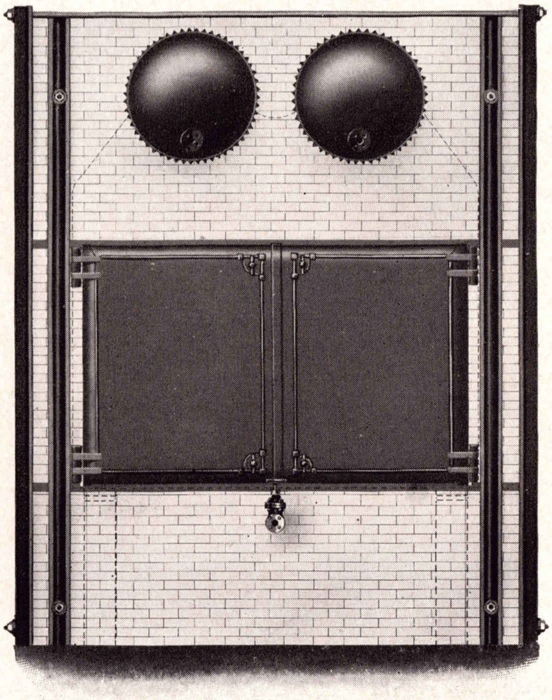
Five 300 H.P. Water Tube Boilers, Illinois Central Railroad Shops, Freeport, Ill.



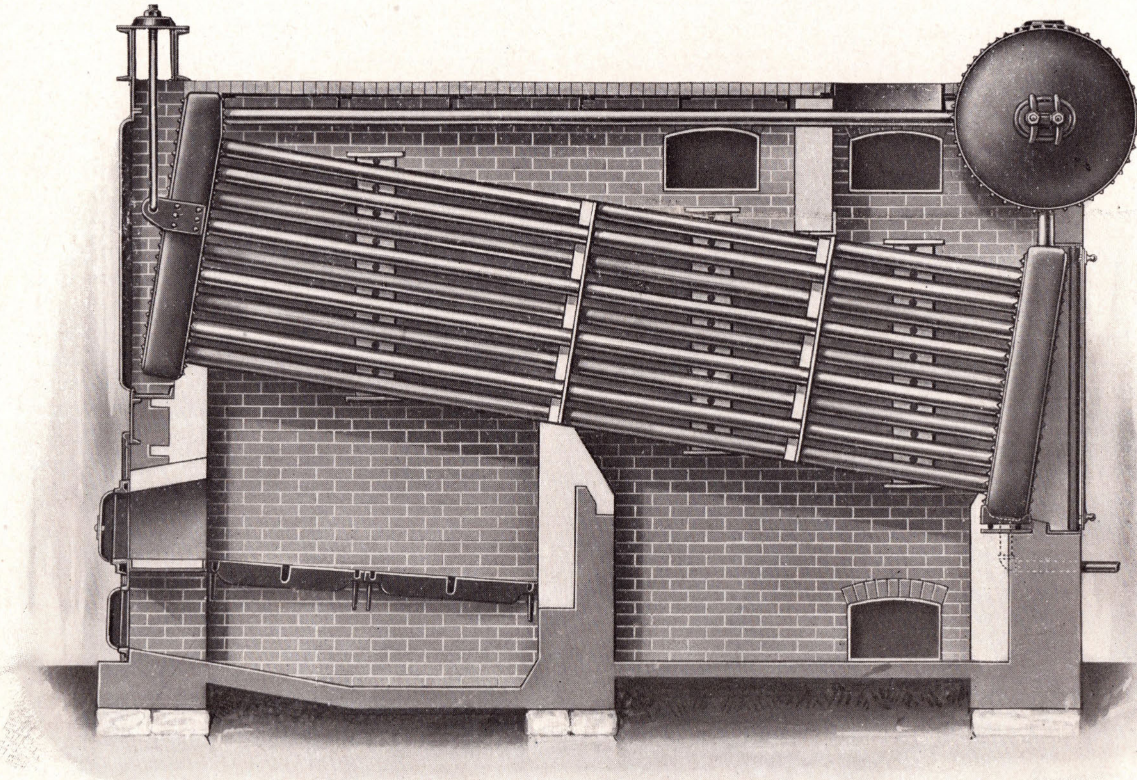
Superheater Attached to C-H Water Tube Boiler

Superheated Steam

SUPERHEATED steam is steam having a higher temperature than the temperature of saturated steam at a given pressure. The degree of superheat is the difference between the temperature of the superheated steam and the temperature of the saturated steam at a stated pressure. Superheated steam possesses the advantage that it cannot condense until it has been reduced to the temperature of saturated steam. The economy of superheat is apparent by the fact that the largest and most economical power plants are equipped with superheaters. The degree of superheat is limited by the increased operating difficulties; maintenance, especially designed apparatuses, piping, lubrication of prime movers, etc., and in actual practice it is a question due to the above conditions whether it is advisable to use superheat over 250 degrees Fahrenheit. All prime movers are more economical when superheated steam is used. It gives up its heat less readily and may be carried a greater distance with less loss than saturated steam. Smaller steam pipes may be used, reducing cost of pipe work. Less boiler horsepower will be required, or boiler horsepower may be increased by the use of superheated steam. Superheated steam in connection with a boiler requires more fuel than the boiler without the superheater. While the net efficiency of the boiler and superheater will be more than the boiler alone, the major gain in superheat is in the operation of the prime mover. Superheaters of any type may be attached to The C-H Water Tube Boiler.



View Showing Rear Tube Doors and Buck Stays



The C-H Cross Drum Water Tube Boiler, Type R 1

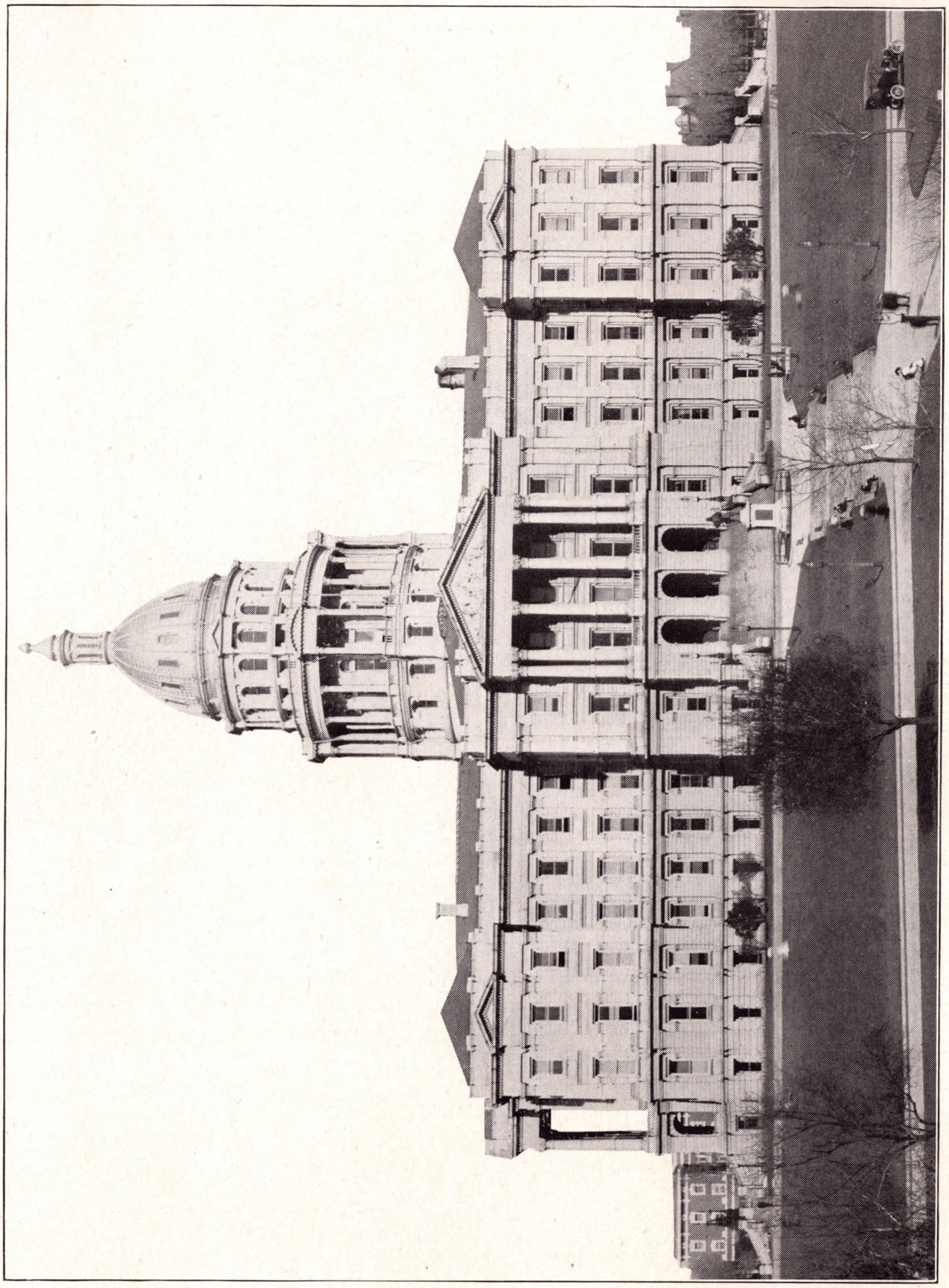
Fuels

THE condensed table No. 4, page 39, gives the approximate composition and calorific value of fuels ordinarily used in boiler practice. The table is classified as follows:

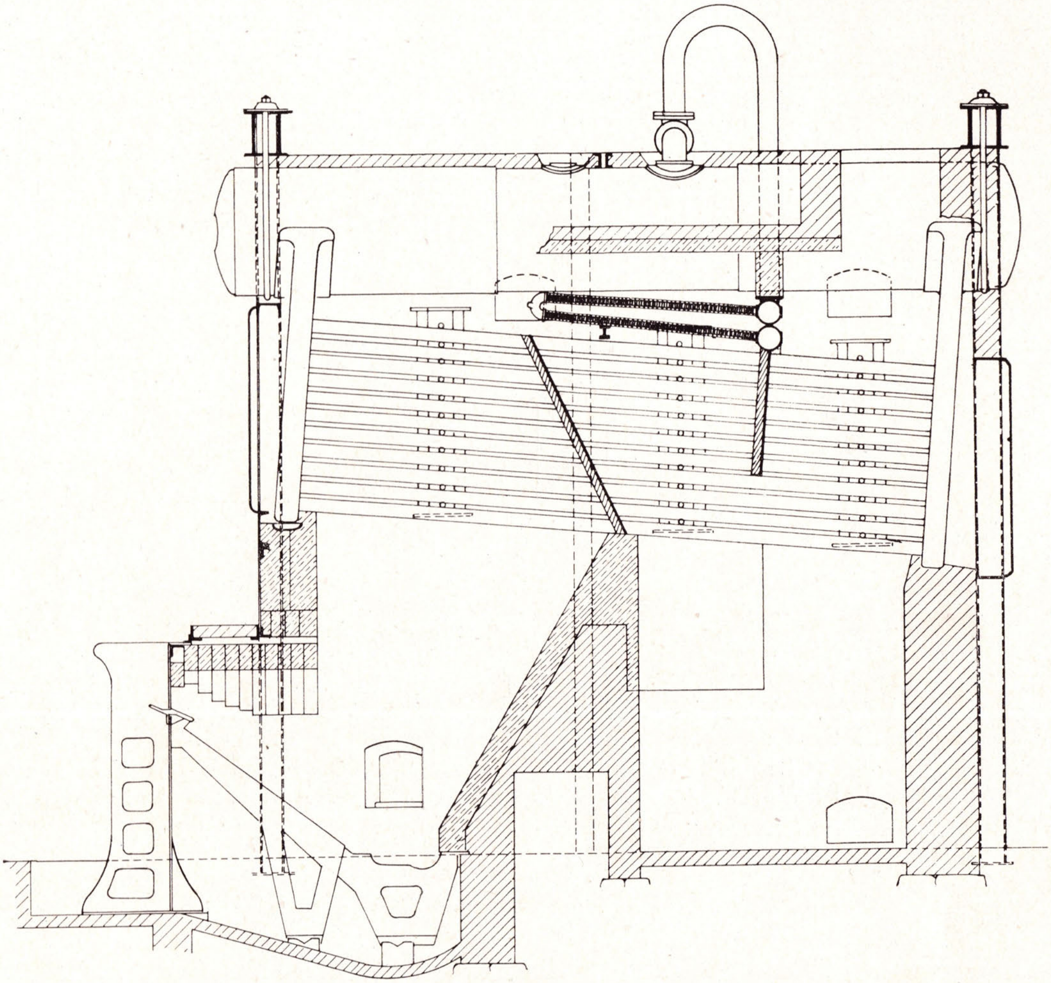
Solid fuels, such as coal, lignite, wood, bagasse, tan bark and sawdust. Liquid fuels are classified as crude oil from the various oil fields. Although coal tar is sometimes used, it is not considered commercially as a fuel. Under the head of gaseous fuels, natural gas and producer gas extracted from the various solid fuels are included. Blast furnace and coke oven gas, waste gases from cement kilns and open hearth furnaces are not included in this heading; these gases are already subject to the process of combustion, having given up part of their heat in the various manufacturing processes in which they are used. It is not our intention to make this article a treatise on the formation of coal and other fuels, but we shall endeavor to describe the conditions necessary for their combustion in a boiler furnace in order to obtain the best results.

ANTHRACITE

Anthracites consist almost entirely of carbon and they are considered the best coals obtainable. They contain practically no volatile matter and might be considered smokeless. They are slow to ignite, do not burn rapidly, and require a larger grate surface than necessary for bituminous coal. On the smaller size, such as Number Three Buckwheat, it is necessary to use a furnace of almost twice the surface required for bituminous coal. Anthracite is frequently mixed with bituminous coal and good results are obtained. This applies especially to the smaller sizes. It is necessary that a high furnace temperature be maintained to insure the ignition of fresh coal. Anthracite should be fired in small quantities and at frequent intervals, evenly over the entire grate surface. The fire should not be sliced and the coal should be disturbed only when cleaning is necessary. For the coarser sizes of buckwheat the ratio should be one square foot of grate surface to thirty-five square feet of heating surface. Where the finer sizes are used, the ratio should be increased to from one to twenty-five. With this ratio, it may be necessary to use grates as long as ten to twelve feet. With the long grates, the rear end should be inclined about 12″ lower than the front end in order that they may be fired easily and it is necessary that some dumping or shaking grate be used in order to clean the fires. Steam jets may be introduced under the grates to lessen the formation of clinker. Forced draft should be used on overload conditions, especially where the finer sizes are to be used. The larger sizes of anthracite, such as egg, stove and chestnut are considered domestic coal and are not used for commercial purposes. The available size of anthracite important for steam generating purposes may be classed as number one buckwheat, number two buckwheat, and number three buckwheat. There are some instances where culm anthracite is being burned underneath boilers, but this grade of fuel requires special furnace construction and conditions out of the ordinary.



Colorado State Capitol Equipped with 700 H.P. C-H Water Tube Boilers



C-H Water Tube Boiler with Rooney Stoker and Foster Super-Heater

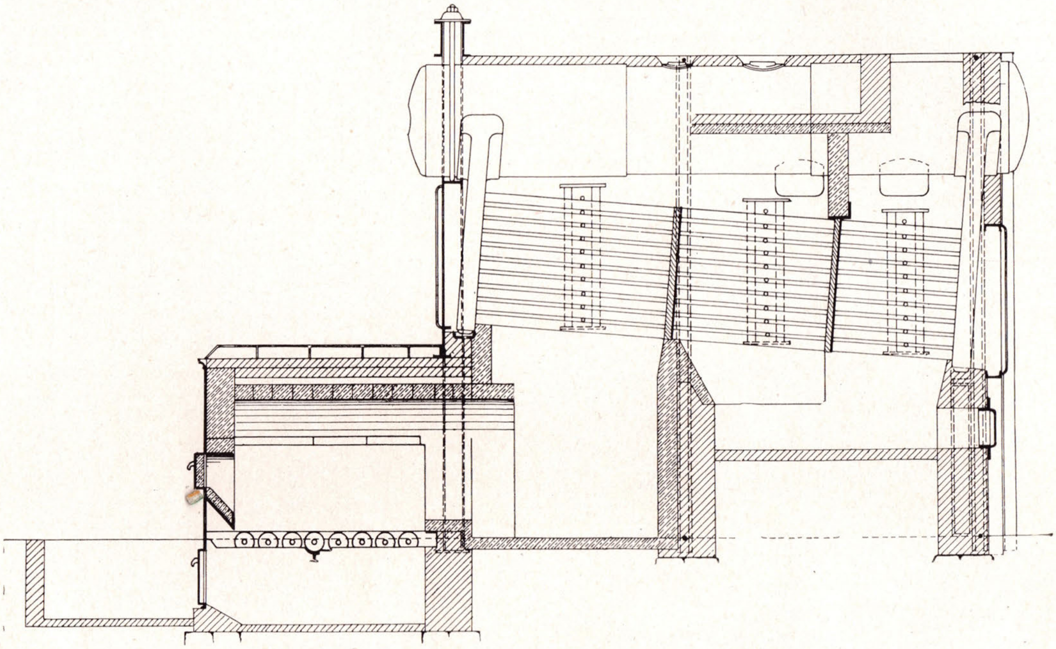
BITUMINOUS COAL

Bituminous coals differ greatly in their characteristics and no set rule of classification can be applied to them. However, they may be classified in a general way as follows:

Class A—Semi-bituminous coals from Pennsylvania, Virginia, West Virginia and Maryland, high in carbon, low in ash and volatile matter.

Class B—Tennessee, Western Pennsylvania, Kentucky, Alabama and Ohio bituminous. These coals have a higher BTU value than Western coals, lower carbon than the semi-bituminous coals and are high in volatile matter, ranging from 30% to 40% volatile matter.

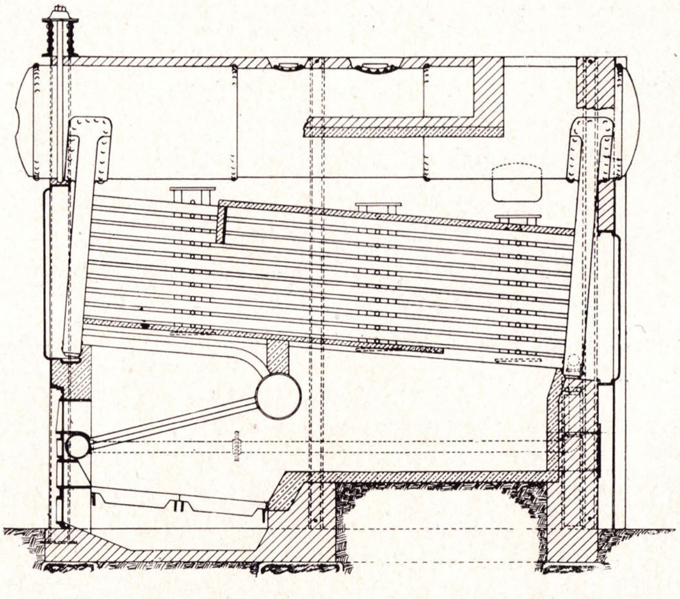
Class C—Illinois, Indiana, and Kansas bituminous. These coals have less than 13,000 BTU's and are high in both ash and volatile matter.



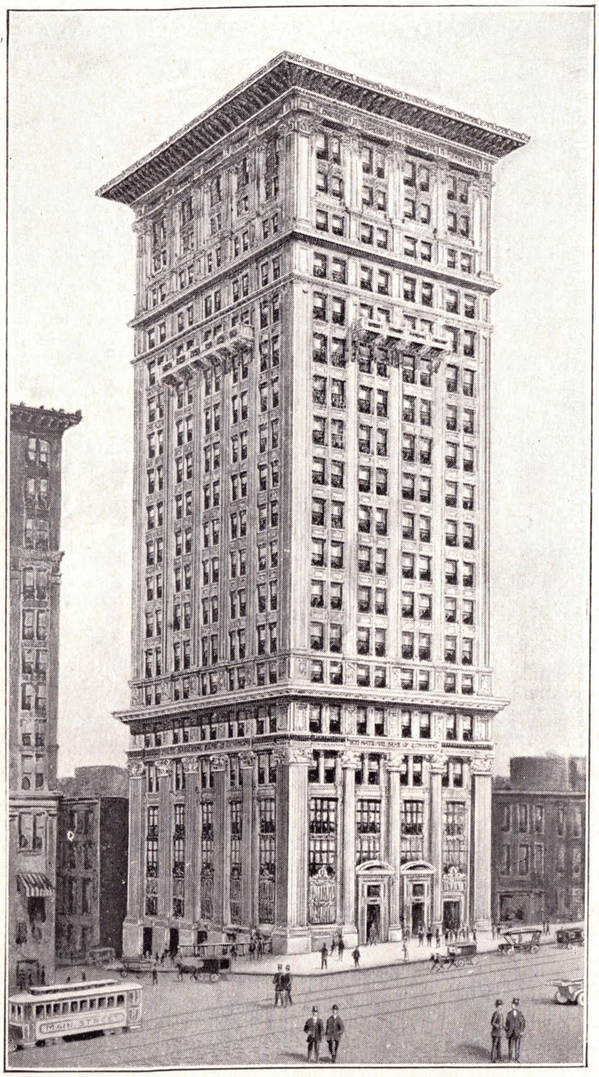
C-H Water Tube Boiler Set with Detroit Murphy Type Stoker and Extension Furnace

Semi-bituminous coals (Class A), which include New River, George's Creek, Pocahontas, etc., are high in carbon, free burning and a fire about 12″ thick should be carried. They should be fired at frequent intervals and should be spread equally over the fuel bed.

Bituminous coals (Class B) from Western Pennsylvania, Ohio, Kentucky and Tennessee should be fired so that a 6″ fuel bed may be maintained, making it necessary to fire at frequent intervals. These coals carry considerable volatile matter, which is given off almost immediately



C-H Water Tube Boiler with Down Draft Furnace



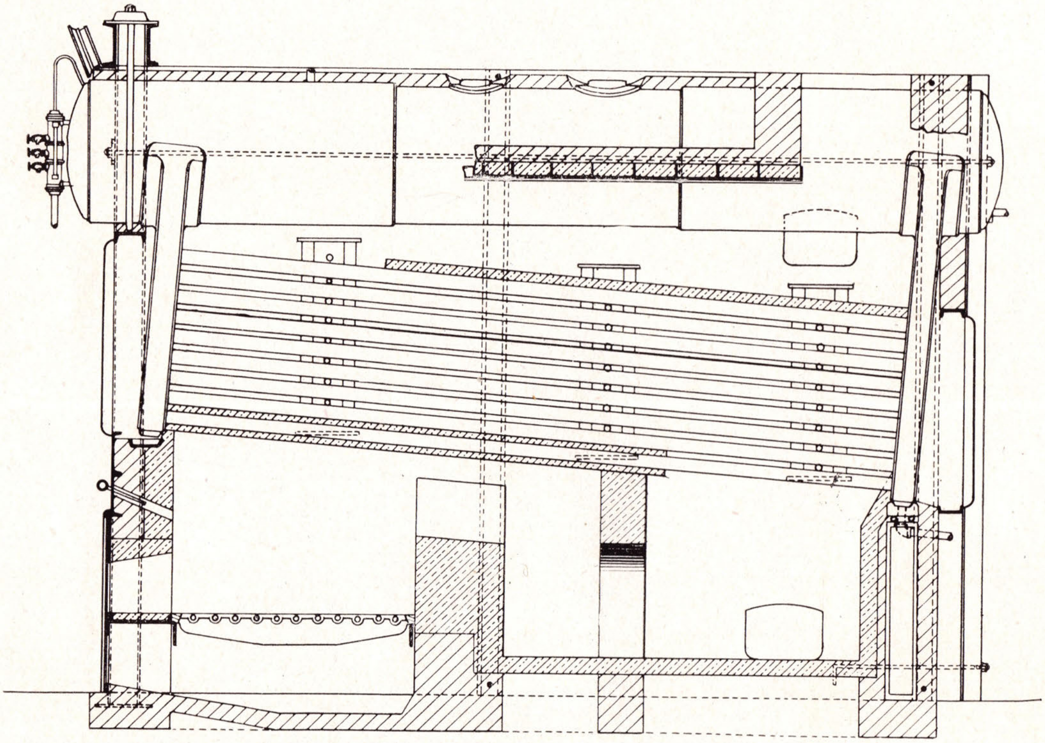
The First National Bank Building, Richmond, Va., Equipped with C-H Water Tube Boilers

as the fuel is placed in the furnace. Ample room should be given for combustion and too much fresh coal should not be fired into the furnace at one time; otherwise, the furnace will be smoky and a large amount of unconsumed gases will pass through the boiler, clogging up the tubes with soot. Not only is part of the heating value of the fuel lost, but the absorbing qualities of the boiler are impaired and its efficiency reduced. Firing large quantities of fuel at one time also increases the tendency to clinker.

Bituminous coals (Class C) from Illinois, Indiana, Kansas and Iowa. These coals are usually high in ash and low in BTU, therefore, it is advisable to use Shaking Grates to eliminate the unnecessary opening of the fire doors and frequent slicing of the fires. Fuel bed of 4″ to 6″ should be carried, spread equally over the entire grate surface. These coals ignite rapidly and burn quickly. They are very successfully burned with chain grate stokers.

COKE BREEZE

Coke breeze from gas plant and by-product coke ovens is frequently used for fuel. It is necessary that a very thin bed of fuel be maintained, with a considerable draft. About 50% more grate surface is required for burning this class of fuel than for burning bituminous coal. Steam jet blowers are frequently used underneath the ash pit. Special types of chain grates have been found to work very satisfactorily with this class of fuel.

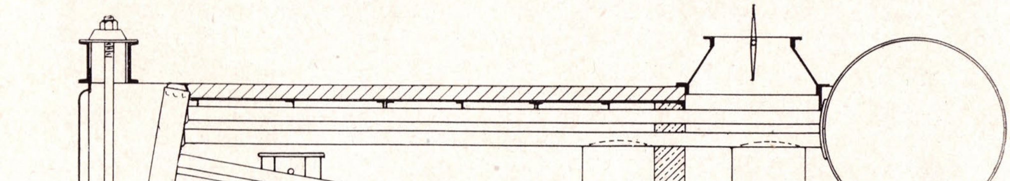


C-H Water Tube Boiler Set with Chicago Smoke Ordinance Furnace

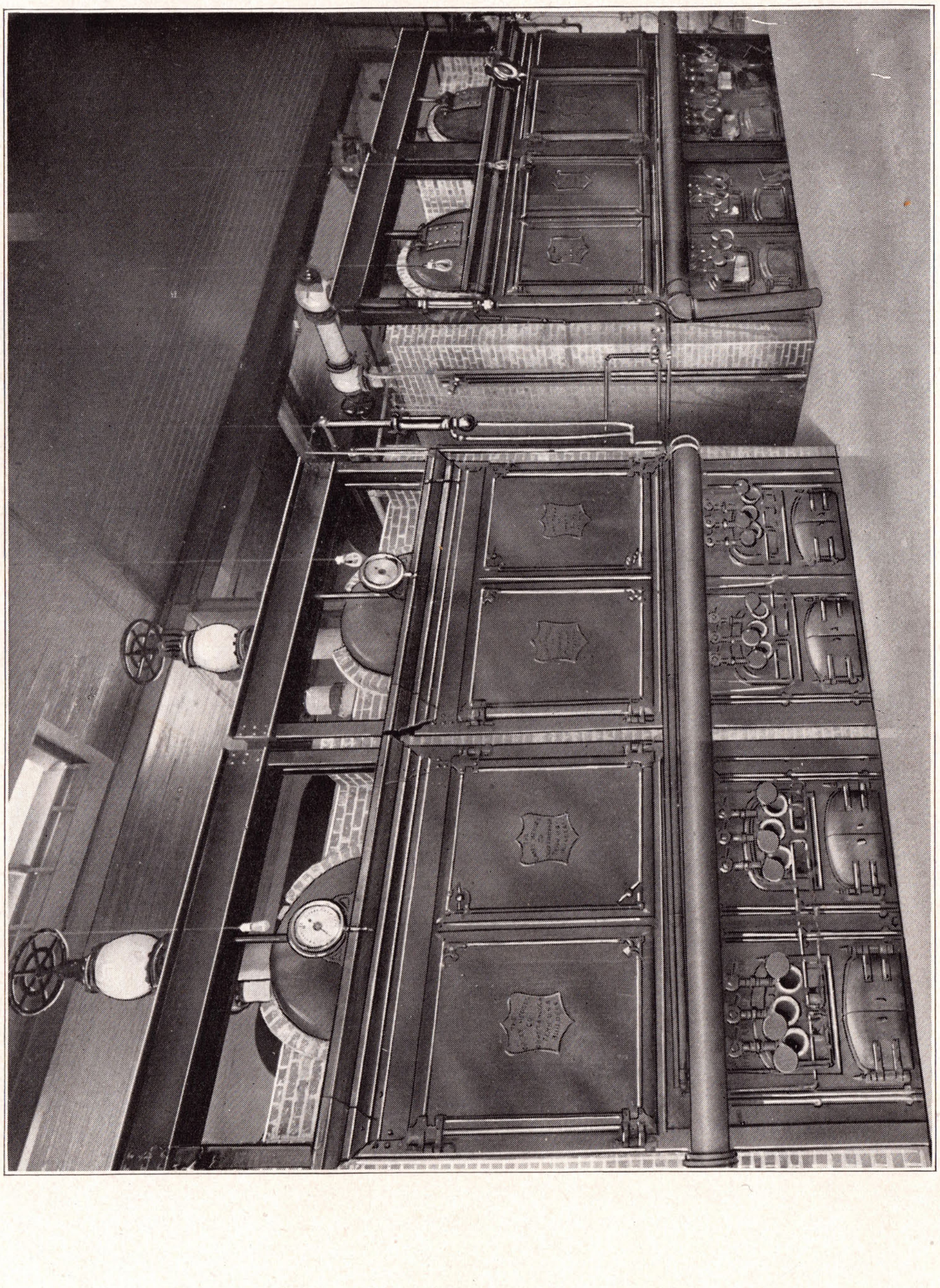
LIGNITES

Lignites are partially formed coal, high in moisture, low in carbon and contain about 10,000 BTU's. This class of fuel can be successfully burned in what is termed a Dutch Oven Furnace. A supplementary combustion chamber is advisable. Shaking grates for cleaning purposes with small air space can be used with good results as this class of fuel is usually high in ash. Coal should be fired approximately 6″ deep at frequent intervals, one side of the furnace being fired at one time instead of firing fresh fuel over the entire surface of the grate. Good results are obtained with this class of fuel with forced draft hollow blast grates.

Kelsey Wheel Company, Memphis, Tennessee, Equipped with C-H Water Tube Boilers



C-H Cross Drum Water Tube Boiler Set with Expanding Type of Furnace and Oil Burner



Municipal Electric Light Plant, Muskogee, Okla., 1000 H.P. C-H Water Tube Boilers Burning Natural Gas

FUELS

TABLE No. 4

SOLID FUELS

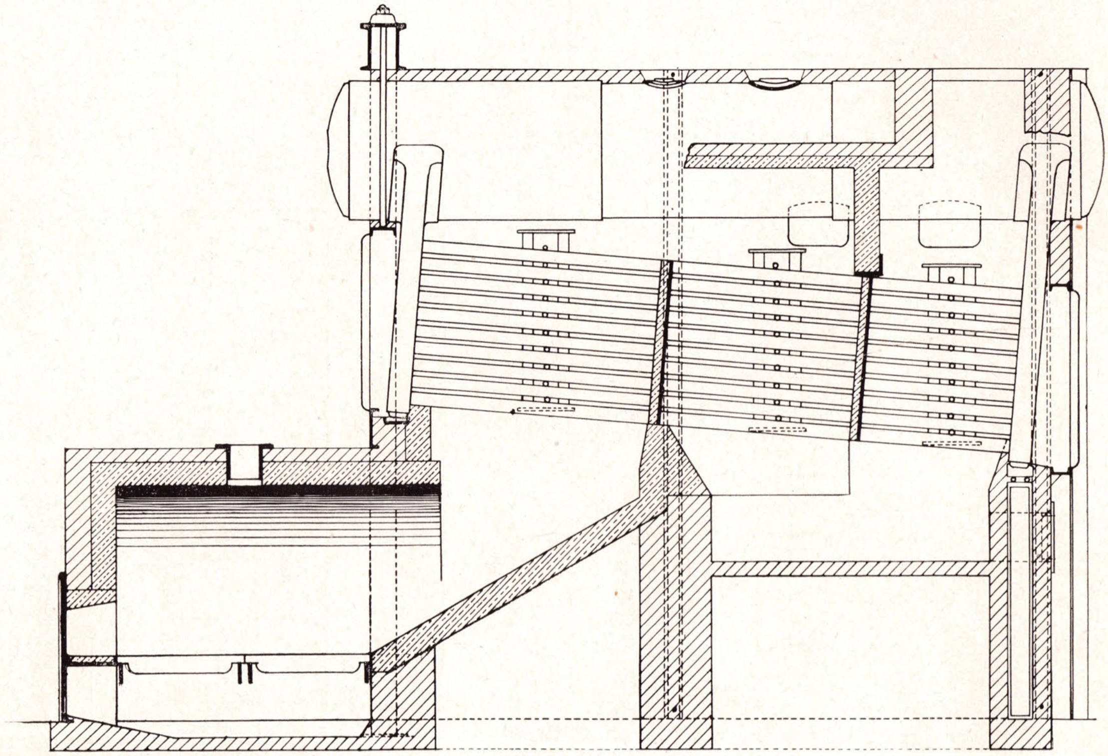
	Approximate B. T. U. per lb.	Ash per cent	Carbon, per cent	Volatile, per cent	Moisture, per cent
Anthracite Coal	14,000	10.	82.	5.	3.
Bituminous Coal—Pocahontas	15,000	6.	76.	14.	4.
Georges Creek	14,500	5.5	75.	16.5	3.
Illinois	11,500	11.	45.	33.	11.
Indiana	13,000	9.	48.	36.	7.
Ohio	12,800	11.	47.	36.	6.
Tennessee	13,500	8.	56.	33.	3.
Kentucky Jellico	14,200	4.	56.	35.	5.
Kentucky Western	13,000	10.	51.	33.	6.
Colorado	11,500	7.	45.	38.5	9.5
Oklahoma	12,300	11.8	49.	32.	7.2
Missouri	12,100	12.	45.	34.	9.
Iowa	11,000	15.5	40.	32.	12.5
Pinewood Sticks, dry	7,300	0.35	40.		20.
Pinewood Sawdust, wet	4,140				54.
Pinewood Sawdust, dry	7,300				20.
Oak Wood Sticks	6,700	0.37			20.
Oak Wood Sawdust, wet	3,600				54.
Oak Wood Sawdust, dry	6,700				20.
Bagasse, Tropical, 75% Extraction, wet	4,650	2.5			42.5
Bagasse, Tropical, 77% Extraction, wet	4,950				39.20
Bagasse, Tropical, 81% Extraction, wet	5,725				30.20
Bagasse, Tropical, 85% Extraction, wet	6,900				16.20
Bagasse, Louisiana, 75% Extraction, wet	3,950	2.			51.
Bagasse, Louisiana, 77% Extraction, wet	4,225				48.
Bagasse, Louisiana, 81% Extraction, wet	4,875				40.2
Bagasse, Louisiana, 85% Extraction, wet	5,900				28.3
Tan Bark, wet	2,700	1.45	52.		65.
Tannic Acid Chips (Chestnut wood), wet	3,600				63.
Lignite Coal, Texas	8,000	11.	28.		34.
Lignite Coal, Montana	10,200	9.	25.		33.
Lignite Coal, Dakotas	10,000	12.	28.		36.
Lignite Coal, Mississippi	9,800	12.	36.		11.5

LIQUID FUELS

	Approximate B. T. U. per pound
Crude Oil, California (Bakerfield)	17,900
Crude Oil, Texas (Beaumont)	19,400
Crude Oil, Pennsylvania	19,210
Crude Oil, Russian	20,090
Crude Oil, Borneo	19,240

GASEOUS FUELS

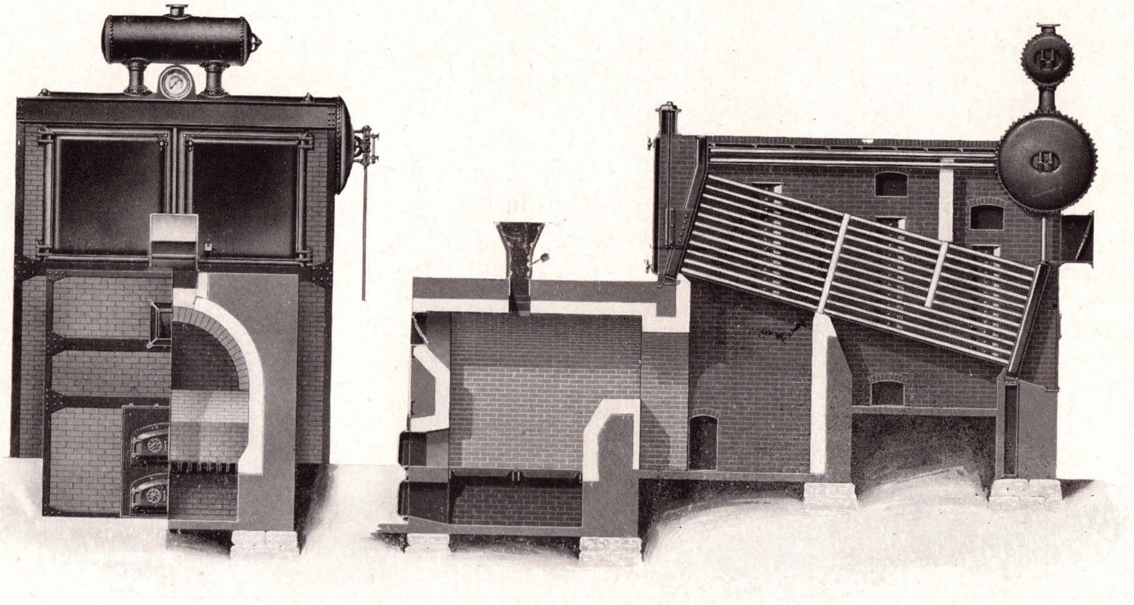
	B. T. U. per cu. ft.
Natural Gas, Low Hydrogen	1,030
Natural Gas, High Hydrogen	890
Producer Gas Anthracite	132
Producer Gas Bituminous	131
Producer Gas Coke	127
Producer Gas Lignite	139
Producer Gas Oil	163
Producer Gas Peat	147
Producer Gas Wood	138
Illuminating Gas Water	313
Illuminating Gas Carbonated Water	618
Illuminating Gas Coal	650
Blast Furnace Gas	98
Coke Oven Gas	450



C-H Water Tube Boiler Set with Dutch Oven Type of Furnace for Burning Sawdust and Refuse Fuel

SAWDUST

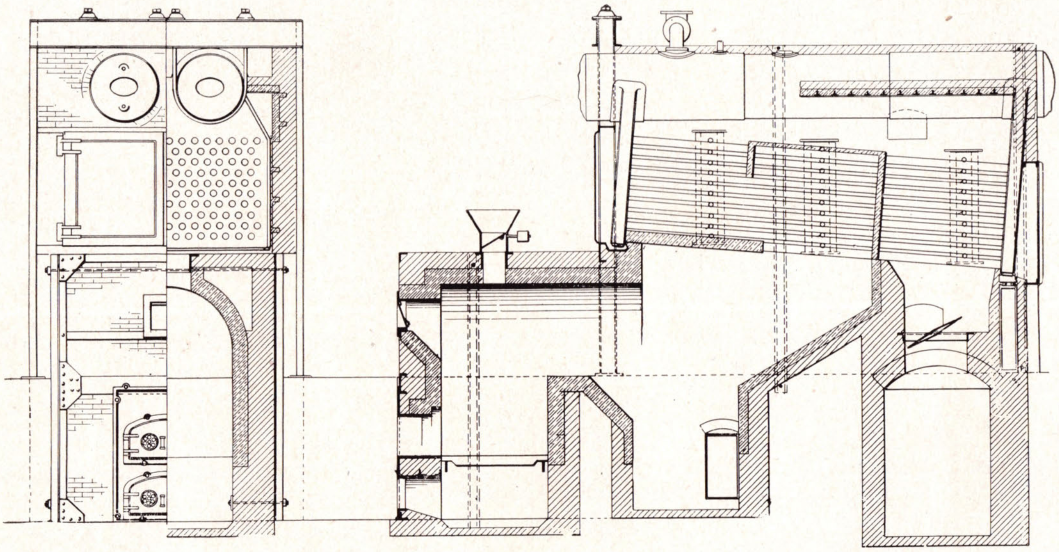
Wood waste from sawmills, planing mills and kindred industries are used for boiler fuel. Woods such as cottonwood, bass wood, buckeye, and gum are more difficult to burn than some of the other wood refuse. Pine, oak, hickory, fir, hemlock, etc., burn readily. Wood refuse from sawmills is usually in the form of sawdust and hogged wood. Hogged wood is the undesirable pieces of wood ground up or shredded in a machine called a hog. This is mixed with the sawdust and constitutes the fuel for operating the ordinary sawmill. This class of fuel requires a large space for combustion. The furnace design is what is termed a Dutch Oven. The moisture in the fuel, which averages about 50% of its weight, is evaporated by the radiant heat from the oven walls. The fuel is fed into the Dutch Oven furnaces by means of a conveyor. Spouts lead from the conveyor to openings in top of the ovens, the fuel falling in a cone shaped mass underneath each opening. The height of the oven should be such that the cone shaped piles spread out enough to cover the entire grate surface. To burn the refuse from mills cutting red gum, cypress, cottonwood, buckeye, etc., it is advisable to use Hollow Blast Grates. The waste from these woods is much harder to burn than pine or oak. With wood waste from sawmills and with properly constructed furnaces, boilers may easily develop 150% of their rated capacity. Our Engineering Department specializes on the design of furnaces for wood waste and we can furnish designs to suit any wood waste fuel.



C-H Cross Drum Water Tube Boiler Set with Furnace Arranged for Burning Bagasse

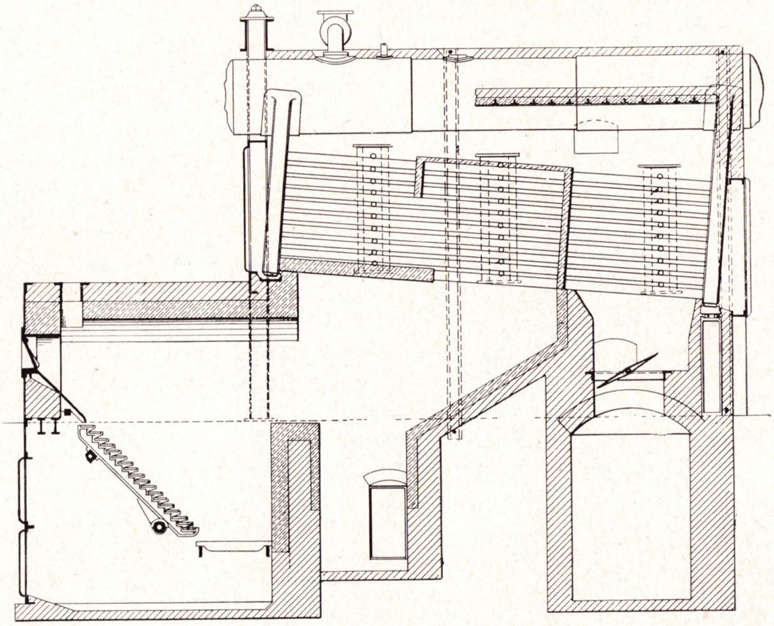
BAGASSE

The refuse from sugar mills after the sugar carrying juices have been extracted from the cane is called Bagasse and is an ideal fuel. There has been numerous claims with reference to the design of furnaces for burning green bagasse. Various forms of so-called patented construction, complicated arch work, systems of forced blast have been tried and found partially successful in burning this fuel. Practically all of the recent installations have been of the Dutch Oven Type with an additional combustion chamber, eliminating the complicated, freakish ideas for which the sugar planter was forced to pay a large sum of money in order to obtain a furnace construction that might burn his bagasse refuse. We are illustrating several types of successful bagasse furnaces. These designs have been tried by us and are in successful operation. Step grate furnace illustrated on Page 43 is a construction that is used in the Hawaiian Islands, Cuba and in a number of the British possessions. It is very successful, although good results are obtained with the plain type grates as illustrated on Page 42. In burning bagasse, a very high rate of combustion is maintained and a grate ratio of 1 sq. ft. grate surface to 100 sq. ft. of boiler heating surface is common. The furnace is much higher than the ordinary Dutch Oven and the height from the top of the grates to crown of arch is usually from 8 to 11 feet. Semi-circular arches are preferred, as they are much stronger than the flat arch. A rather high bridge wall is used, about 4 feet above the grates. From this bridge wall, the gases are led into a combustion chamber. The arch from the main furnace usually extends backward to form the roof of the combustion chamber. Curtain walls or drop arches are sometimes provided in the combustion chamber to act as mixers, but these soon burn out. The furnace should be substantially buck-stayed and tied together with a structural frame work of angles. The furnace front is much heavier than the ordinary fire front. Both fire and ash doors should be large for cleaning purposes. In the combustion chamber a large size cleaning door should be provided for the removal of ash and clinker. $\frac{3}{4}''$ air space in the grates is found to give the best results. Wood doors for firing in cord wood are provided in the front near the top of the arch. These doors are the self-closing type. The wood being in heavy sticks and dropped a great distance, it is necessary that the grates be very heavy. Owing to the fact that a small amount of grate surface is required as compared with the boiler heating surface, frequently one furnace is provided for two boilers. In fact, it is found that better results are obtained with one furnace for two boilers rather than a furnace for each boiler.



C-H Horizontal Water Tube Boiler with Furnace Arranged for Burning Bagasse, Underground Smoke Flue

With .35 of 1 inch of water, about 300 pounds of bagasse can be consumed per sq. ft. of grate surface per hour. With forced draft, a combustion rate of 460 pounds per sq. ft. of grate surface per hour is possible. This is based on bagasse of 75% extraction. Bagasse is usually fed into the furnaces by means of a hopper provided with dumping door with counter-weight. There are several types of mechanically driven bagasse feeders or hoppers on the market. These hoppers can be controlled to feed a given amount of bagasse per hour. The construction of these hoppers is such that air is kept from entering the furnace. Their use is recommended.

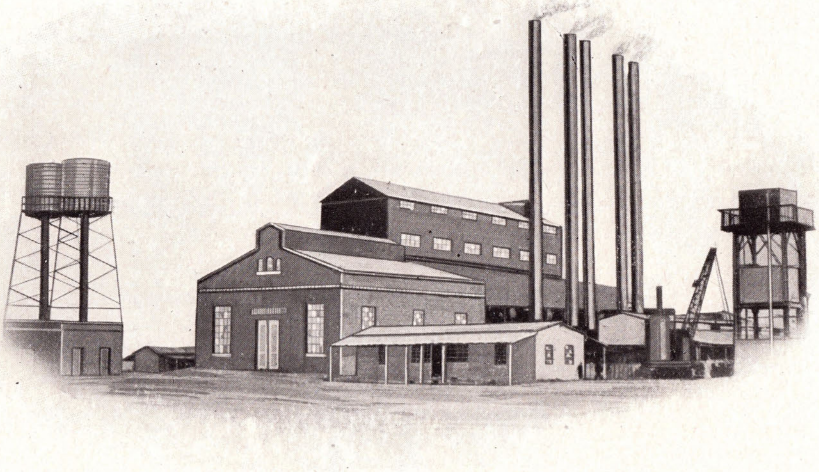


Step Grate Bagasse Furnace

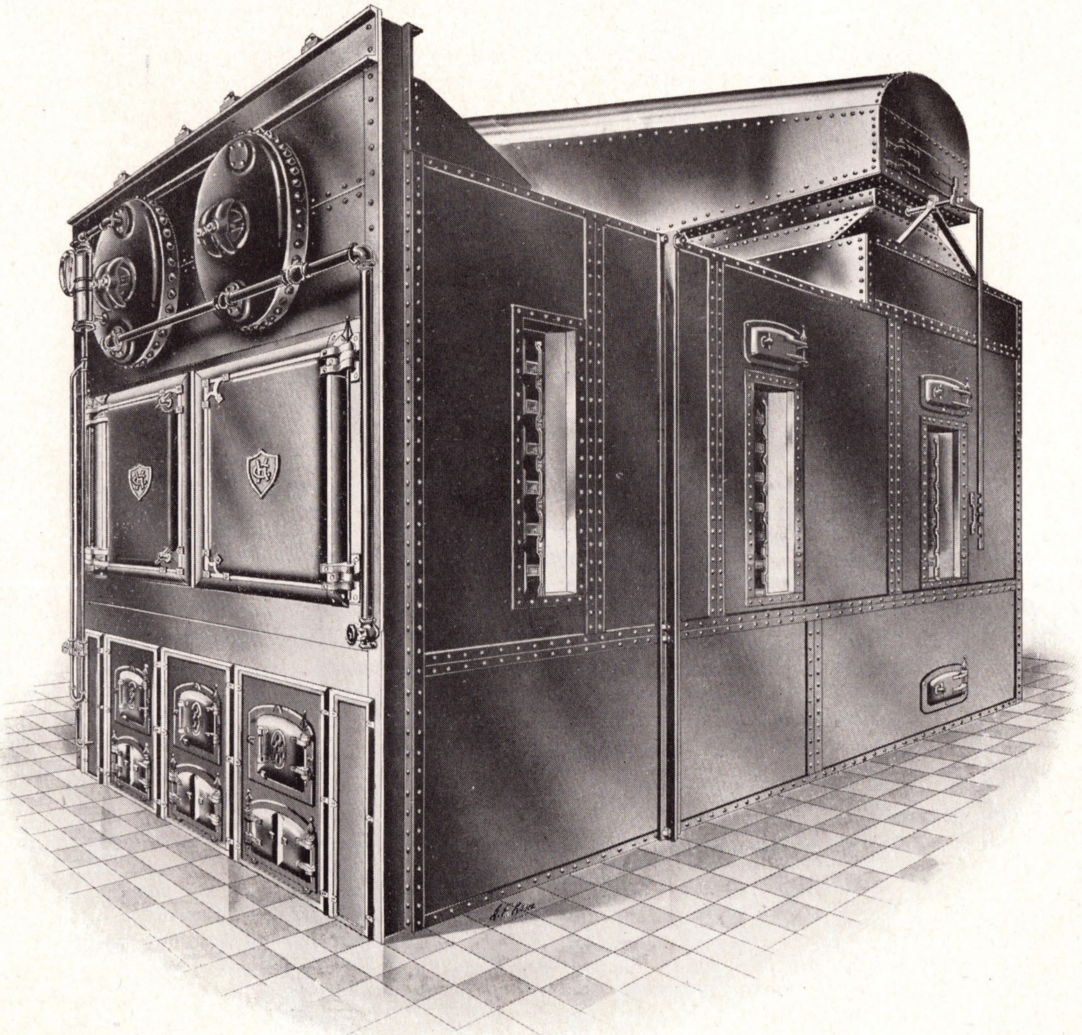
SPENT TAN AND CHIPS FROM WHICH THE TANNING HAS BEEN EXTRACTED

This class of fuel averages about 65% moisture and has a heating value of 3,300 BTU's when wet. In burning this class of fuel, furnaces of the Dutch Oven type are used. The tan bark is usually supplemented by a small amount of coal in order to keep the gas ignited. We have several designs of furnaces for burning tan, all in successful operation. The Riddell Furnace is particularly suited for burning chestnut wood chips from which the tannic acid has been extracted. The construction is different from the regular tan furnace.

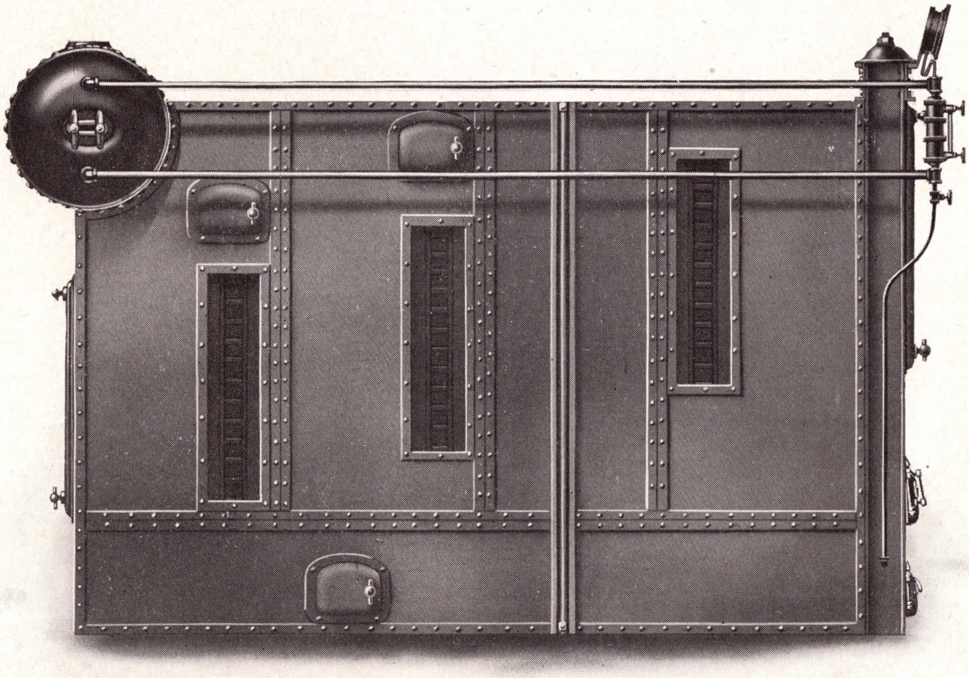
We can also furnish furnaces suitable for burning Quebracho wood chips from which the tannic acid has been extracted. This wood is found in South America and furnaces for burning this class of fuel require special construction.



Plant of International Products Company, Puerto Pinasco, Paraguay, S. A.
Boilers Equipped with Furnaces for Burning Quebracho Wood Chips



C-H Horizontal Water Tube Boiler Fitted with Steel Casing

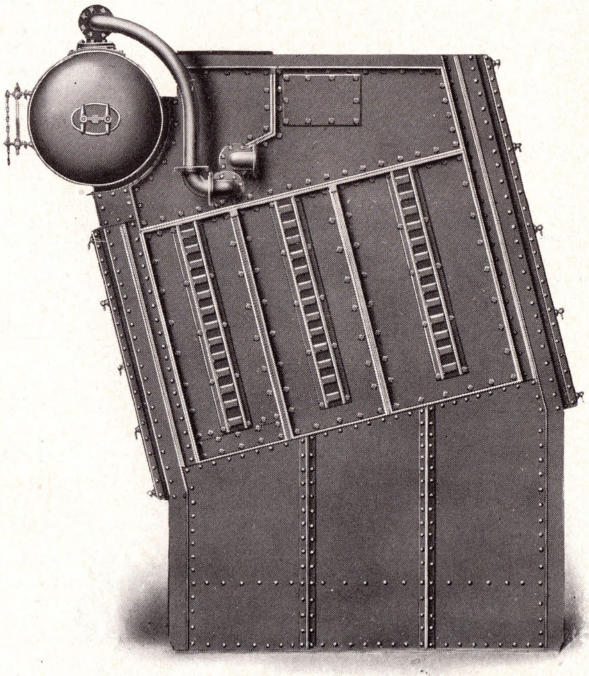


C-H Cross Drum Water Tube Boiler Fitted with Steel Casing

The C-H Steel Casing

THE steel encased boiler setting is the latest and most improved method of setting Water Tube Boilers. No matter how well-designed the setting may be, if it is not air tight, the maximum results will not be obtained. The ordinary brick setting may be of the best workmanship, but it is not air tight. In time, cracks will appear and allow cold air to enter into the interior of the setting with its harmful effects. All excess air entering into the setting must be brought up to the furnace temperature and it takes fuel to do this. The steel encased boiler setting overcomes all trouble due to leaky brick work, reduces the maintenance cost and increases the efficiency of the boilers. The usual saving in fuel is approximately from 7½ to 10% and a steel casing at this rate will soon pay for itself.

The designs shown are for the ordinary hand-fired type of furnace. They can be modified so as to accommodate stokers and any other special condition.



C-H Marine Water Tube Boiler with Super-Heater

C-H Marine Water Tube Boiler

THE C-H Marine Water Tube Boiler is of all steel construction throughout, it being a modification of our Cross Drum Water Tube Boiler to meet marine conditions. The tubes are 3″ in diameter and vary in length from 8′ to 12′, depending upon the size and design of the boiler. The boiler is fired at the lowest end and the furnace is of the expansion type and the baffling is what is known as the Combination Baffling. The peculiar furnace construction adapts it admirably to either coal, oil or wood as a fuel.

The handhole caps are what are known as the Key Handhole Caps, requiring no gaskets. It is of the inside type, which tends to tighten under pressure, there being a handhole cap opposite each end of each tube.

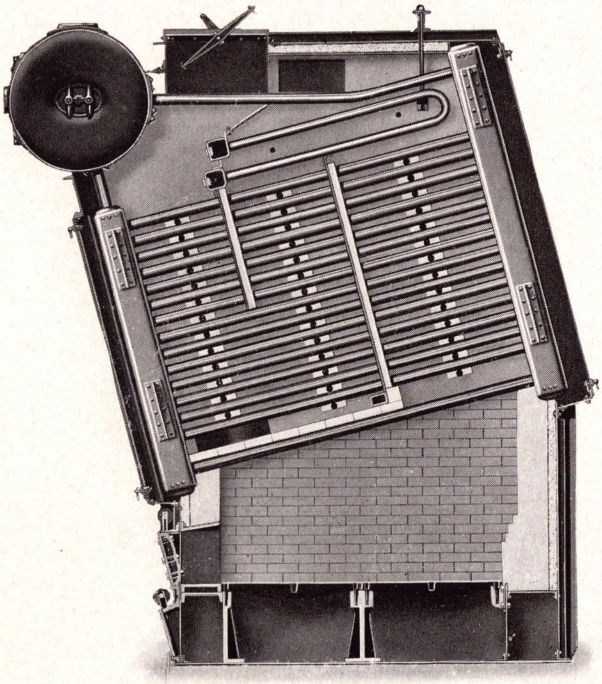
Special attention is paid to the baffle construction. The design of the baffles are such that the baffles may be replaced by new ones with ease at any time.

The sectional steel casing is built up on a structural frame work and parts may be removed whenever desired.

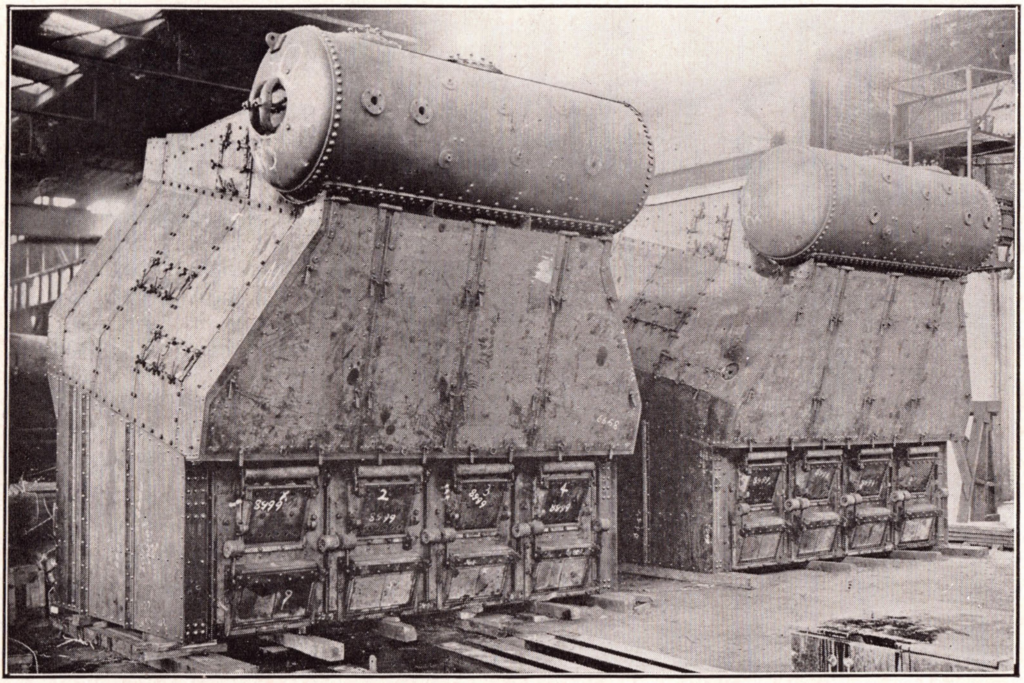
The boiler is built for pressures 200, 225 and 250 lbs. per sq. in. in accordance with the Rules and Regulations of the United States Board of Supervising Inspectors, Lloyd's requirements, or any other special marine requirements.

The heating surface may vary from 1,000 to 8,000 sq. ft.

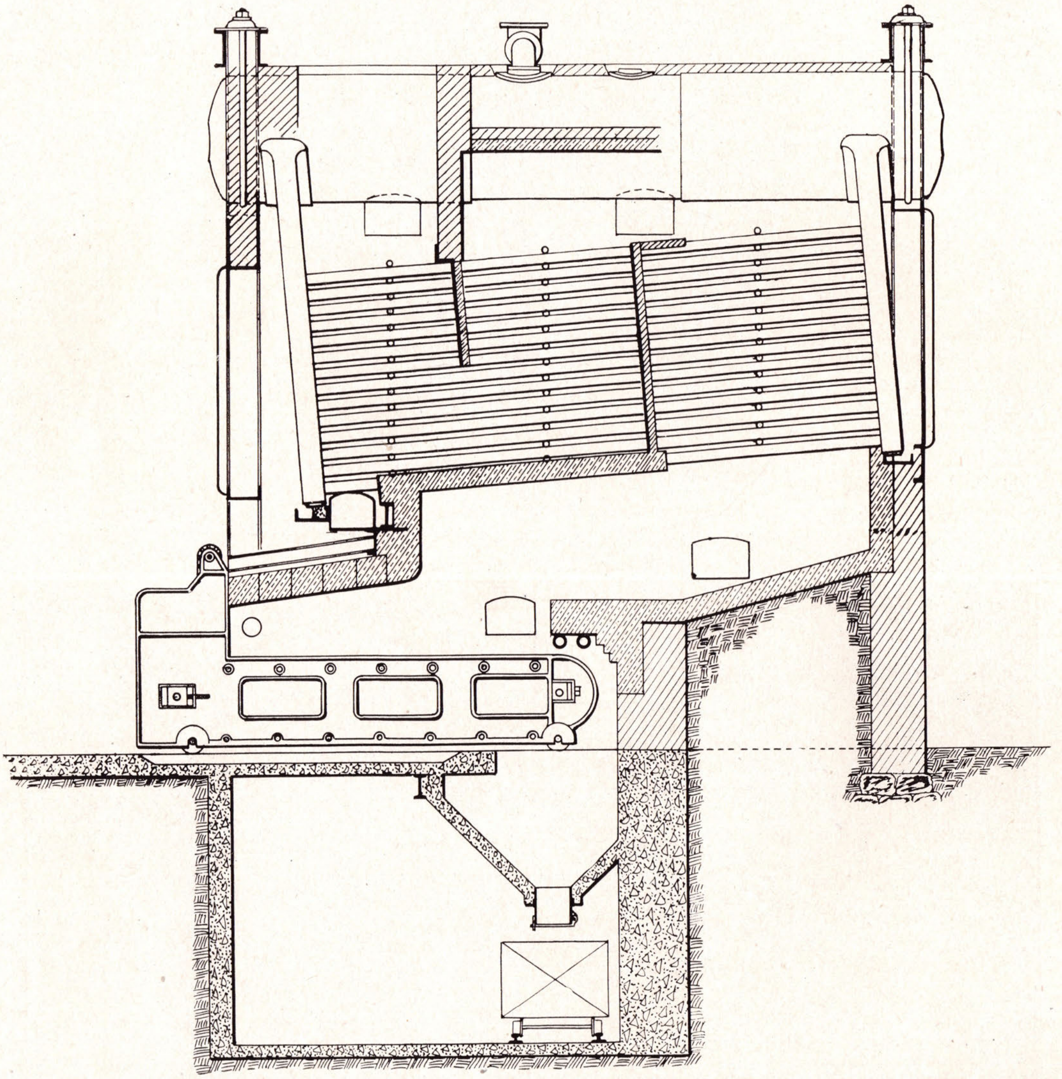
The boiler is fitted with a full complement of marine fittings and spare parts as desired.



Sectional View of Marine Type Water Tube Boiler



Two of Fifty Conti Type Marine Water Tube Boilers built for the United States Shipping Board, Emergency Fleet Corporation



C-H Horizontal Water Tube Boiler with Chain Grate. Tubes Inclined Towards Front End

Boiler and Furnace Testing

By Rufus T. Strohm, U. S. Bureau of Mines

NECESSITY FOR TESTING BOILERS

A boiler test is necessary in order to determine how well the boiler is doing the work expected of it; that is to say, we must find out whether we are wasting coal in making steam and how much this waste may be. Such a test may be made to discover the efficiency of the boiler, or the quantity of water it is evaporating, or the cost of evaporating 1,000 pounds of water.

The United States Fuel Administration recommends that every boiler plant have some means of daily checking the efficiency of the boiler and furnace. The simplest and best way of finding out how efficiently the boiler is working is to make an evaporation test, as described in this bulletin. All the necessary records can be made automatically with suitable instruments, although in many small plants the coal must be weighed on ordinary scales. The efficiency of the furnace can be found by making analyses of the flue gases. (See Bulletin No. 2 of the United States Fuel Administration.)

Too many engineers and firemen have the idea that they are not fitted to make boiler tests. This is altogether wrong. Any man who can weigh water and coal and read steam gages and thermometers is able to do the work required in making a boiler test for evaporation or efficiency. Such a test requires a knowledge of the following:

1. The total weight of coal used.
2. *The total weight of water fed to and evaporated by the boiler.
3. The average temperature of the feed water.
4. The average steam pressure in the boiler.

If these four items are known, a series of simple calculations will show how much water is being evaporated per pound of coal, and the efficiency of the boiler and furnace.

To make a test, the following apparatus and instruments are necessary:

1. Scales to weigh the coal.
2. Apparatus to weigh or measure the feed water.
3. Thermometers to take feed-water temperature.
4. Gages to indicate steam pressure.

A boiler test to be of value should extend over a period of at least eight hours. The longer the test the more accurate the results.

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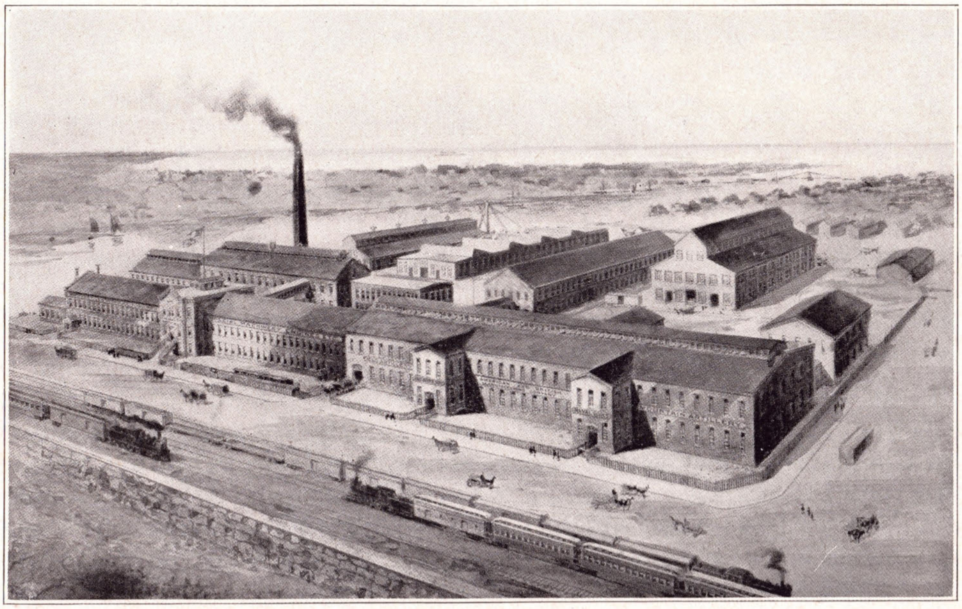
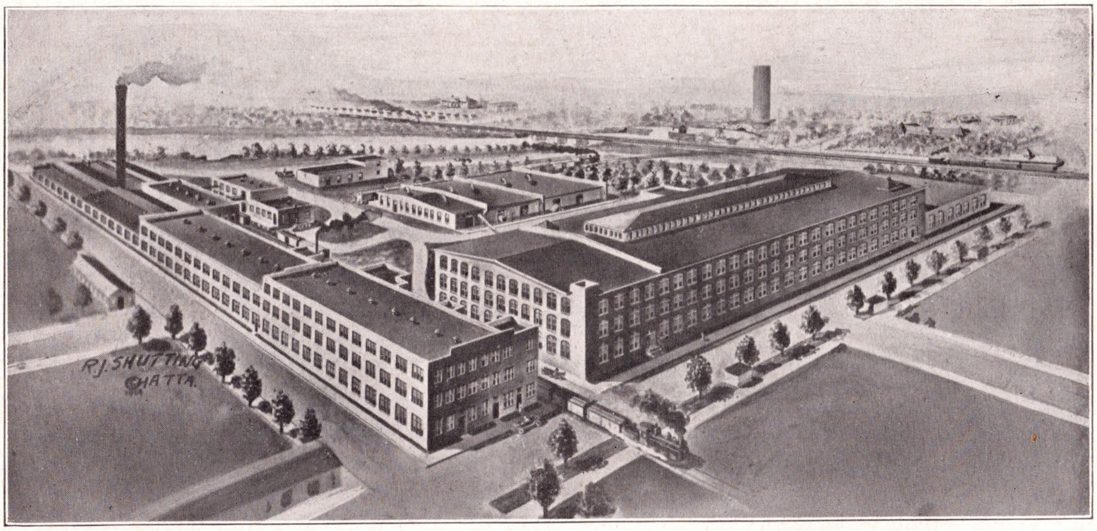
*For the sake of simplicity, only the essential elements of boiler and furnace testing are treated in this bulletin. For rules covering the refinements for an exhaustive test, the reader is referred to the boiler test code of the American Society of Mechanical Engineers. Copies of this code can be obtained from the Secretary, 29 West Thirty-ninth Street, New York City.



Plant of the American & British Mfg. Co., Bridgeport, Conn., Equipped with C-H Water Tube Boilers



Crystal Springs Bleachery, Chickamauga, Ga., Equipped with C-H Water Tube Boiler

WEIGHING THE COAL

The weight of coal used during a test may easily be found by using an ordinary wheelbarrow and a platform scales, arranged as in Figure 1. At each side of the scales build an incline with its top level with the top of the platform, but take care not to have either one touch the platform. Set the empty wheelbarrow on the scales, run the movable weight or poise out until it exactly balances the weight of the barrow and lock it in position with the thumbscrew.

Next, put weights on the scale pan A to correspond to a net weight of 250 or 300 pounds of coal. Fill the barrow with coal, run it on the scales, and add coal or take off coal until the scales balance. This is easily done by having a small pile of coal B beside the scales. If the weights on the scale pan represent, say, 300 pounds, the net weight of coal in the barrow is exactly 300 pounds. This coal is wheeled in front of the boiler and dumped on the clean floor, and the barrow is returned for another load.

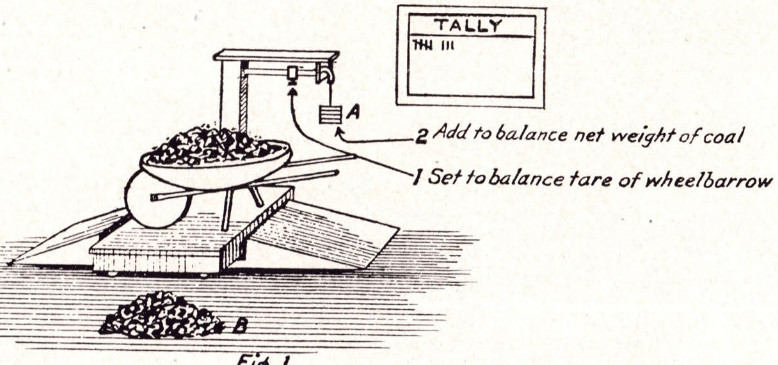
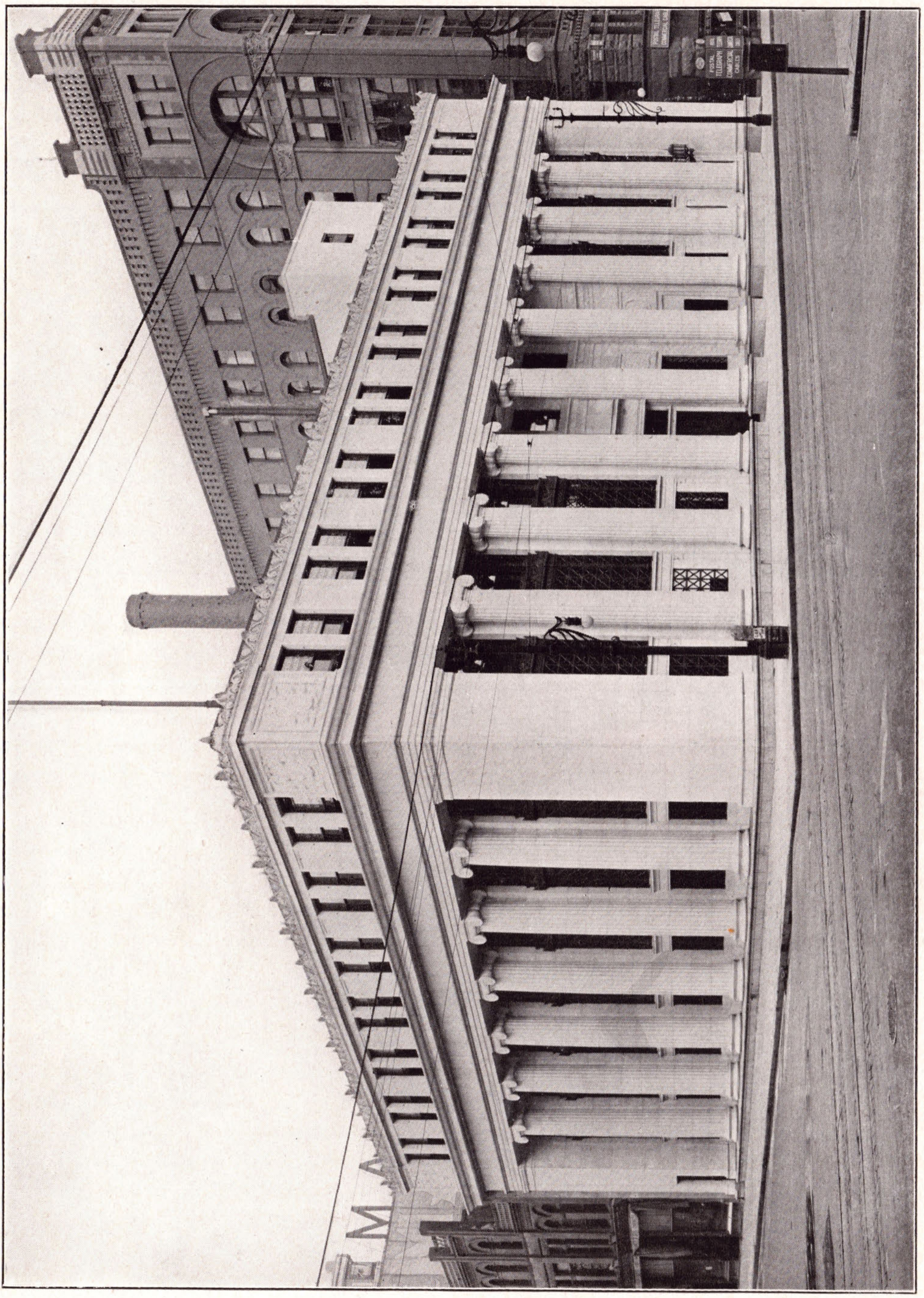

TALLY
𝍸 III
A
2 Add to balance net weight of coal
1 Set to balance tare of wheelbarrow
B

Fig. 1.

Each time the barrow of coal is weighed on the scales and taken to the boiler being tested, a tally mark should be made on a board nailed to the wall beside the scales. Each tally mark represents 300 pounds of coal, since the amount of coal in the barrow is adjusted at each weighing, so that the scales just balance. At the end of the test, therefore, the number of tally marks is multiplied by 300, and the product is the weight of coal used, provided it has all been fired; but if any coal remains in front of the boiler at the close of the test, it must be gathered up and weighed, and its weight must be subtracted from the total weight indicated by the tally marks to get the number of pounds of coal actually fired. You should, of course, start the test with no coal in front of the boiler.

Care must be taken not to forget to make a tally mark each time a barrow of coal is run off the scales. By setting the scales so as to show any net weight, such as 250 or 300 pounds, and making each barrow load exactly this weight, much time is saved, as it is unnecessary to change any of the weights or the position of the rider on the scale beam.

If the coal used in the test is to be analyzed, take a sample of from 4 to 6 pounds from each barrow and throw it into a box near the scales. Do this BEFORE the coal is weighed. These small amounts from the various barrow loads will then give a fair average sample of the coal used during the test.



Colorado National Bank Building, Denver, Colorado, Equipped with C-H Horizontal Water Tube Boilers

The condition of the furnace should be the same at the end of the test period as at the start. Therefore, at the moment the test is begun, observe the thickness of the fuel bed and the condition of the fire. If the fire was cleaned, say, an hour before the test began, see that it is cleaned an hour before the time when the test is scheduled to end. If the coal was fired, say, eight minutes before the test started, the last coal used during the test should be fired eight minutes before the end of the test. The object of these precautions is to insure the same conditions at start and finish, as nearly as possible; otherwise, the coal weighed will not be the same as the coal consumed.

MEASURING THE FEED WATER

The quantity of water fed to the boiler during the test may be found by metering or by weighing. A reliable water meter is recommended for this work. There are a number of good makes, of different types, such as:

1. Venturi meter.
2. Weir or V-notch meters.
3. Diaphragm meters.
4. Displacement meters.
5. Water weighers.

The best form of meter to use in any particular case depends on the local conditions in the plant; but EVERY PLANT SHOULD BE PROVIDED WITH A PERMANENTLY INSTALLED METER OF SOME TYPE. The displacement form of meter should be used only with cold water, however.

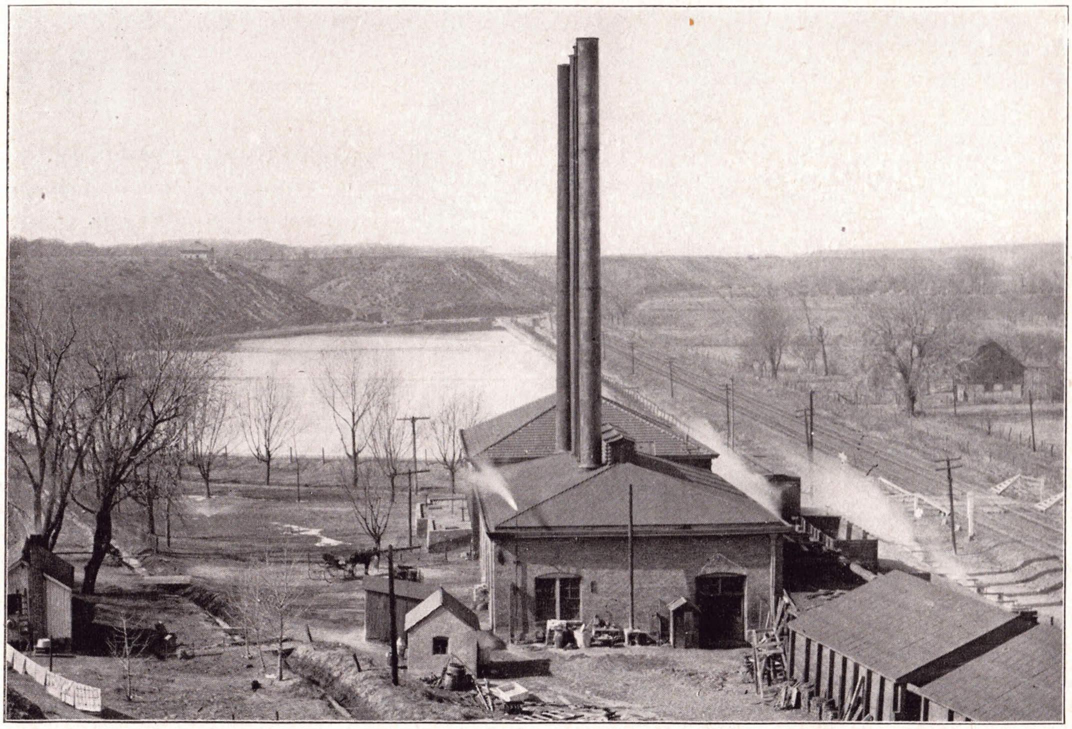
If there is no meter or water weigher in the plant, the feed water used during the test can be measured by the three-barrel arrangement illustrated in Figure 2.

Obtain three water-tight barrels, and set two of them close together on a platform directly over the third, leaving about 12 inches above barrel 3 in which to fit the valves V and the nipples in the bottoms of barrels 1 and 2. Near the top of each of the barrels 1 and 2 screw a 1-inch overflow pipe O.

Run a pipe P from the city main or other source of supply above barrels 1 and 2, and put a valve A on the pipe leading to each barrel. From barrel 3 run a suction pipe to the feed pump that is to pump water to the boiler to be tested. It is best to have a by-pass from the usual water supply direct to the feed pump, or to another pump connected to the boiler, so that in case of any trouble with the testing barrels, the regular operation of the boiler may be resumed without shutting down.

The next step is to fill barrels 1 and 2 with water until they overflow at O. This water should be of practically the same average temperature as that which is to be used during the test. Barrel 3 should be high enough above the feed pump so that the pump will handle hot water. Put barrel 3 on a scales, before connecting it to the feed pump, and weigh it. Then let the water from barrel 1 run into barrel 3, and weigh again. The second weight minus the first weight is the net weight of water run in from barrel 1 and is the weight of water contained in barrel 1 when filled to the overflow. The weight of water in barrel 2 when it is filled to the overflow can be found in like manner. Mark these weights down.

Bar Mill Southern States Steel Company, Gadsden, Alabama, Equipped with C-H Horizontal Water Tube Boilers



Municipal Water Works Plant, Pueblo, Colorado, Equipped with C-H Horizontal Water Tube Boilers

When the net weights are found and barrel 3 is removed from the scales and connected to the feed pump, the apparatus is ready to begin the test. Start with the level of the water about 1 foot below the top of the barrel 3, and drive a nail into the barrel to mark this level. When the test is finished, the level should be brought to the same point, so that the water that has passed through barrels 1 and 2 will accurately represent the weight of water fed to the boiler during the test.

When the test is to begin, stop the feed pump and tie a string around the gage glass on the boiler to mark the height of the water level in the boiler. Then start the pump connected to barrel 3. Fill barrels 1 and 2 up to the overflow before the test is started. Then open the valve V on barrel 1 and let the water run into barrel 3 as fast as the feed pump draws water from barrel 3. When barrel 1 is emptied close its valve V and open its valve A so as to refill it.

While barrel 1 is filling empty barrel 2 into barrel 3 in the same way, and continue to fill and empty barrels 1 and 2 alternately. In this way barrel 3 will be kept supplied with water that has been measured in barrels 1 and 2, the net weights of which were found before the test began. Keep a separate tally of the number of times each of the barrels 1 and 2 is emptied into barrel 3. At the end of the test the number of tallies for each barrel multiplied by the weight of the water that barrel will hold will be the weight of water measured in that barrel. The sum of these weights for barrels 1 and 2 will be the weight of water used in the test.

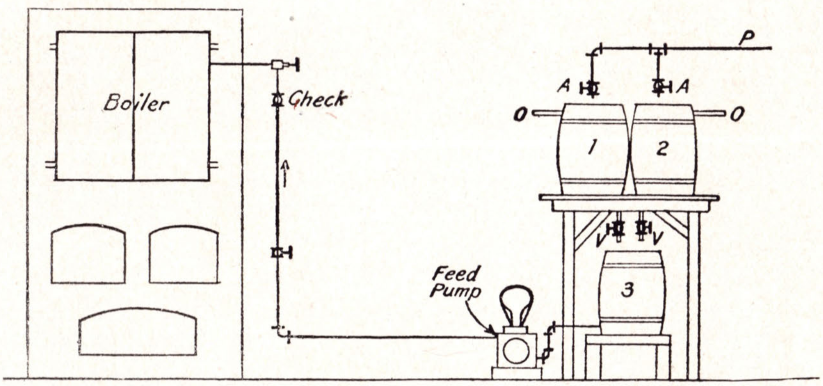
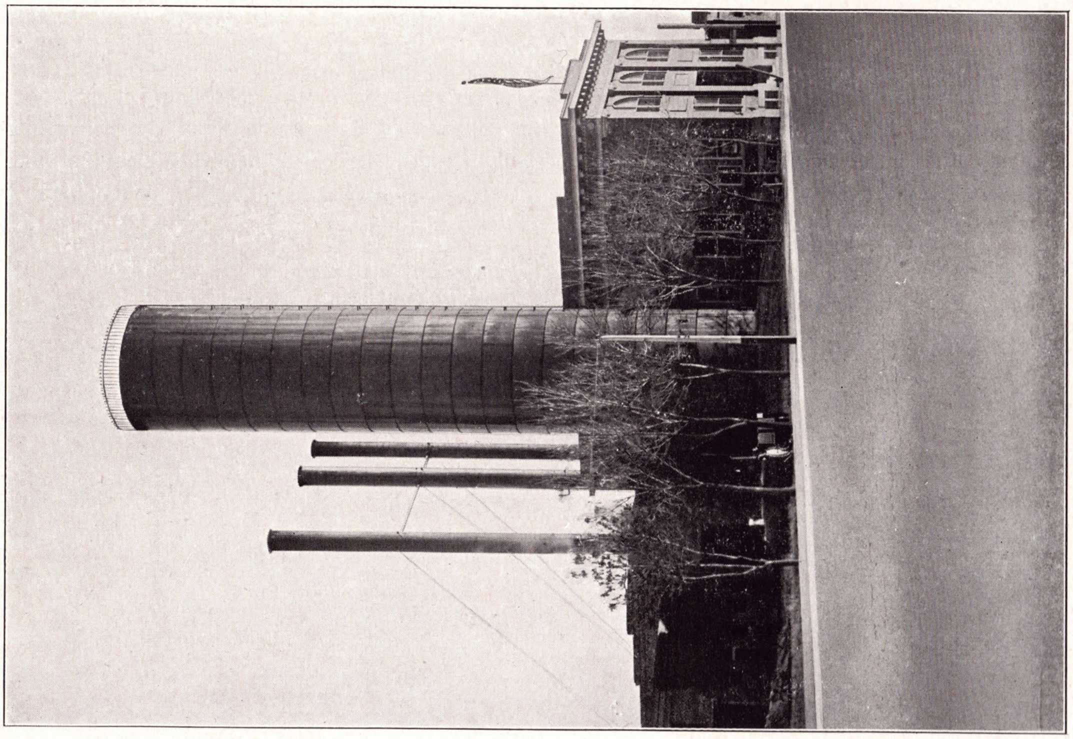


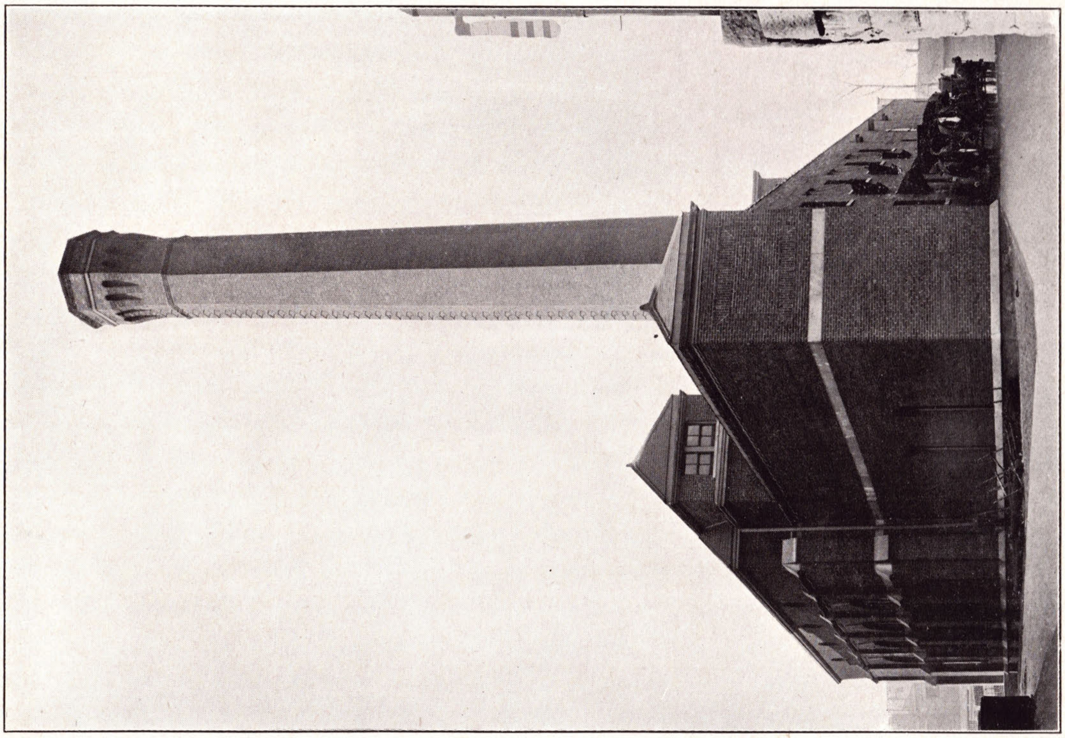
Fig. 2.

With a three-barrel arrangement like this, water can be weighed rapidly enough to supply 300 boiler horsepower.

Before starting a test make sure that there is no chance for water to leak into or out of the boiler. See that the blow-off is tight, that there is no drip from gage cocks, and that the feed-line connections are tight, so that all the water fed to the boiler will represent accurately the amount evaporated during the test.



Municipal Water Works, Fort Morgan, Colorado, Equipped with C-H Water Tube Boilers



Englewood High School, Chicago, Illinois, Equipped with C-H Water Tube Boilers

If a meter is used instead of the three-barrel method, make absolutely sure that the meter is correct, as the accuracy of the test depends on the accuracy with which the water measurements are made. AFTER A METER IS INSTALLED, TEST IT TO SEE THAT IT OPERATES CORRECTLY UNDER THE PLANT CONDITIONS.

The water level in the boiler should be the same at the end of the test as at the beginning. As the time for stopping the test draws near, therefore, try to bring the conditions the same as at the start. Do not, however, run the feed pump rapidly in the last few minutes for the test in order to obtain the same water level. If there is a slight difference in level, calculate the weight of water it represents and make the necessary correction to the total weight of water fed.

TEMPERATURE OF FEED WATER

Every plant should have a thermometer on the feed line, so as to find the temperature of the feed water. Preferably, this thermometer should be of the recording type. If such a form of thermometer is used during the test, it is unnecessary to take the feed temperature at stated intervals, as the record will show the varying temperatures, and so the average feed temperature during the test can easily be found.

If there is no thermometer in the feed line, take the feed-water temperature by means of a thermometer hung in barrel 3 (Figure 2) by a hook over the edge of the barrel. Read this thermometer every half hour during the test if the feed-water temperature is fairly uniform; but if it varies considerably, read the thermometer every 15 minutes. The object is to obtain the average feed-water temperature during the test period. Therefore, mark down the temperatures as read at stated intervals. At the close of the test add the readings and divide their sum by the number of readings and you will have the average temperature of the feed water.

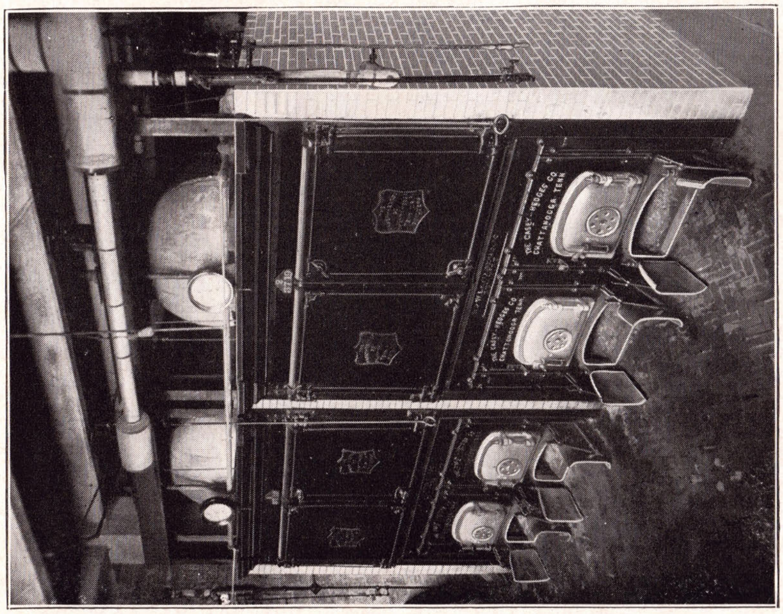
STEAM PRESSURE

Every boiler is fitted with a steam gage by which the pressure is indicated. It is important that the pressure gage be accurate. What is wanted in a test is the average pressure of the steam in the boiler, therefore, observe the pressure at regular intervals, just as with the feed-water temperature, and mark down these gage readings. The sum of the readings divided by the number of readings taken will be the average steam pressure during the test.

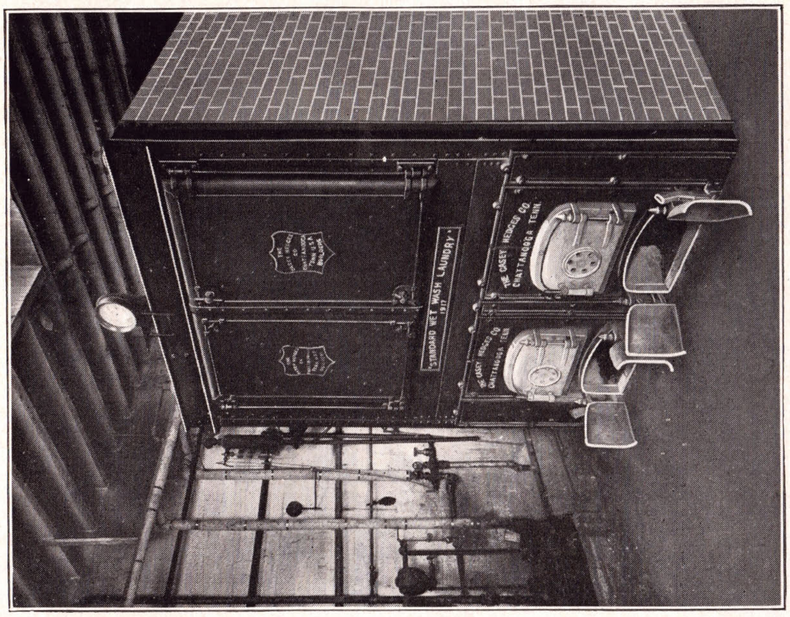
A recording steam gage is best and makes its own readings.

WORKING UP THE TEST

After the boiler test has been made, so as to find the weight of coal burned, weight of feed water used, feed-water temperature and steam pressure, the efficiency, the horsepower, and the economy must be obtained by calculation from the test results. The process of figuring the desired results from the test data is called "working up the test."


THE CASEY-HEDGES CO.
CHATTANOOGA, TENN.

New York Linen Supply & Laundry Company, Equipped with two 330 H.P. C-H Horizontal Water Tube Boilers


STANDARD WET WASH LAUNDRY
1917
THE CASEY-HEDGES CO.
CHATTANOOGA, TENN.

Standard Wet Wash Laundry Equipped with one 250 H.P. C-H Cross Drum Water Tube Boiler

To illustrate the method used in finding the efficiency, etc., suppose that the data obtained from the test are as follows:

Length of test	hours	10
Total weight of coal fired	pounds	5,000
Total weight of water evaporated	do	35,000
Average temperature of feed water	°F	180
Average steam pressure, gage	pounds per square inch	100

The efficiency of any process is always a comparison, or ratio, of the output to the input. In the case of a steam boiler the efficiency is the percentage of the heat supplied in the coal that is usefully employed in making steam. The output of the steam boiler is the heat represented by the quantity of water evaporated by a pound of coal, taking into account the feed temperature and the steam pressure, and input is the amount of heat contained in a pound of the coal used. The efficiency of the boiler is the output divided by the input.

The heat contained in a pound of coal is called the "calorific value" or "heating value" of the coal. It can be found by taking a fair average sample of the coal used during the test, as explained in connection with weighing the coal, and sending the sample to a chemist, who will make a calorimeter test to determine its heating value.

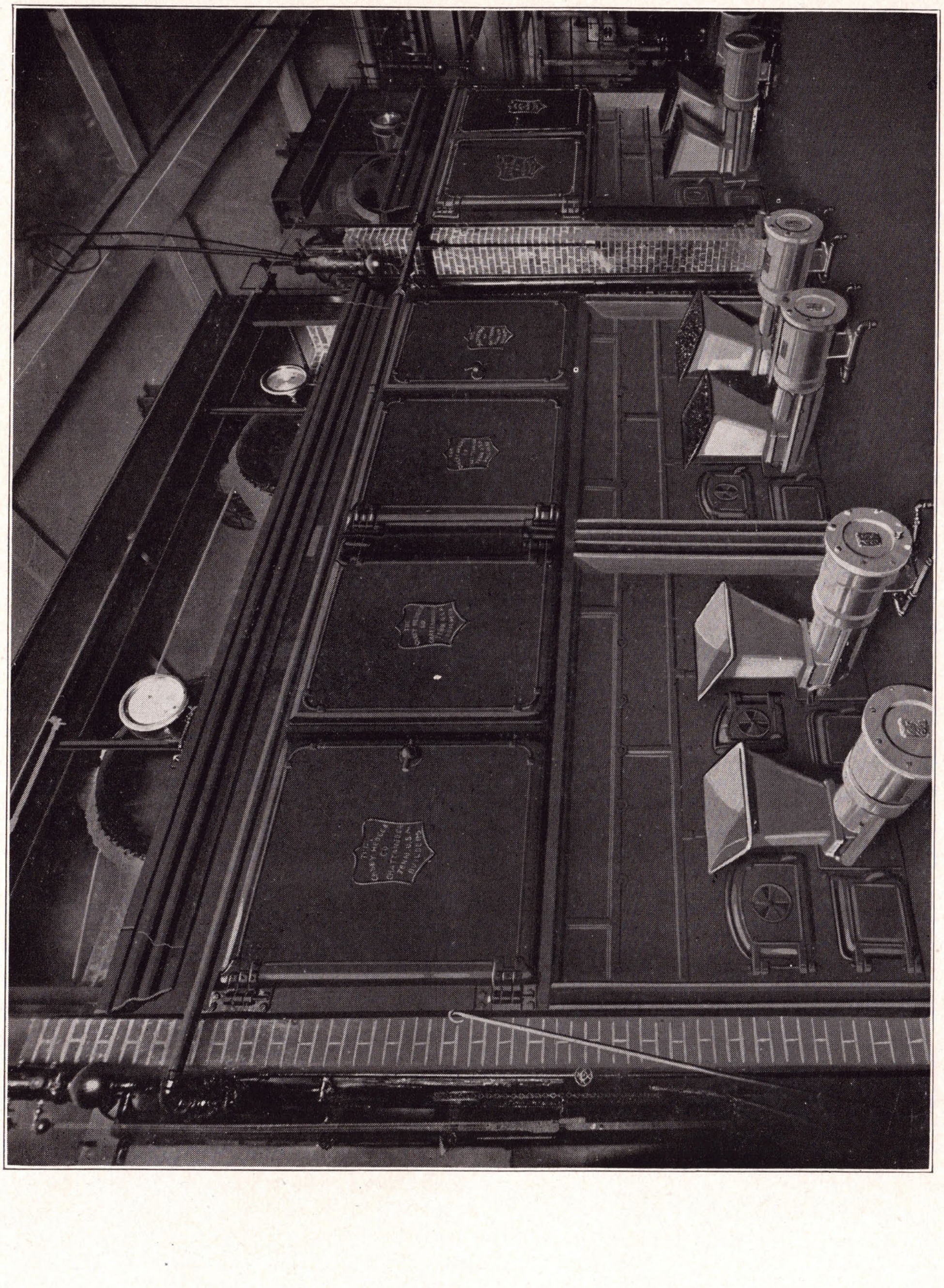
At the end of the test the sample fuel should be spread out on a clean floor and all lumps broken up, so that no pieces are larger than 2 inches maximum diameter. Then the gross sample should be very thoroughly mixed by shoveling, after which it should be spread out in the form of a square of uniform depth and quartered down until a final average sample is obtained for shipment to a competent chemist, experienced in fuel analysis. (See Bureau of Mines Technical Paper No. 133.)

About 2 quarts of the chemist's sample should be put in air-tight tins or jars for the determination of moisture; the balance of the sample (the total weight of which should be from 10 to 50 pounds, depending on the total weight of coal used in the test) may be packed in a wooden box lined with paper to prevent splinters from mingling with the sample. A duplicate coal sample should be kept at the plant to be used in case of loss of the sample sent to the chemist.

The Bureau of Mines has published a bulletin or pamphlet giving the analyses and heating values of the various kinds and grades of coal from all parts of the United States. (Bureau of Mines Bulletin No. 22). This bulletin can be used to learn the approximate heating value of the coal. Simply find out what district the coal used in the test came from, and its grade, and then refer to the bulletin to obtain the heating value of the coal. If a chemist can be obtained to make a heat test, however, it is better to use the heating value he determines.

Suppose that during the test the coal used was run-of-mine bituminous having a heating value of 13,500 B. t. u. Every pound of coal fired, then, carried into the furnace 13,500 heat units, and this value therefore is the INPUT to be used in calculating the boiler efficiency.

During the test 5,000 pounds of coal was fired and 35,000 pounds of water was fed and evaporated. This means that $35,000 \div 5,000 = 7$ pounds of water was evaporated per pound of coal burned. This is the "actual evaporation," and the heat required to evaporate this 7 pounds of water is the output to be used in calculating the efficiency.



Boiler Plant of The Colorado State Museum, Denver, Colo. Four 300 Horse Power C-H Water Tube Boilers with Jones Under-Feed Stokers

Every fireman knows that it takes more coal, and therefore more heat, to make steam with cold feed water than with hot feed water; also, that it is somewhat easier to make steam at a low pressure than at a high pressure. So it is plain that the heat required to evaporate 7 pounds of water into steam depends on two things, namely (1) the temperature of the feed water and (2) the pressure of the steam in the boiler. From the data of the test, both the average feed-water temperature and the average steam pressure are known, and so it is a simple matter to find out the amount of heat needed to evaporate 7 pounds of water from the average temperature to steam at the average pressure.

A pound of water at 212° F. must have 970.4 B. t. u. added to it to become a pound of steam at 212° F., or zero gage pressure. This value, 970.4 B. t. u., is called the latent heat of steam at atmospheric pressure, or the heat "from and at 212° F." It is the heat required to change a pound of water FROM 212° F. to steam AT 212° F., and is used by engineers as a standard by which to compare the evaporation of different boilers.

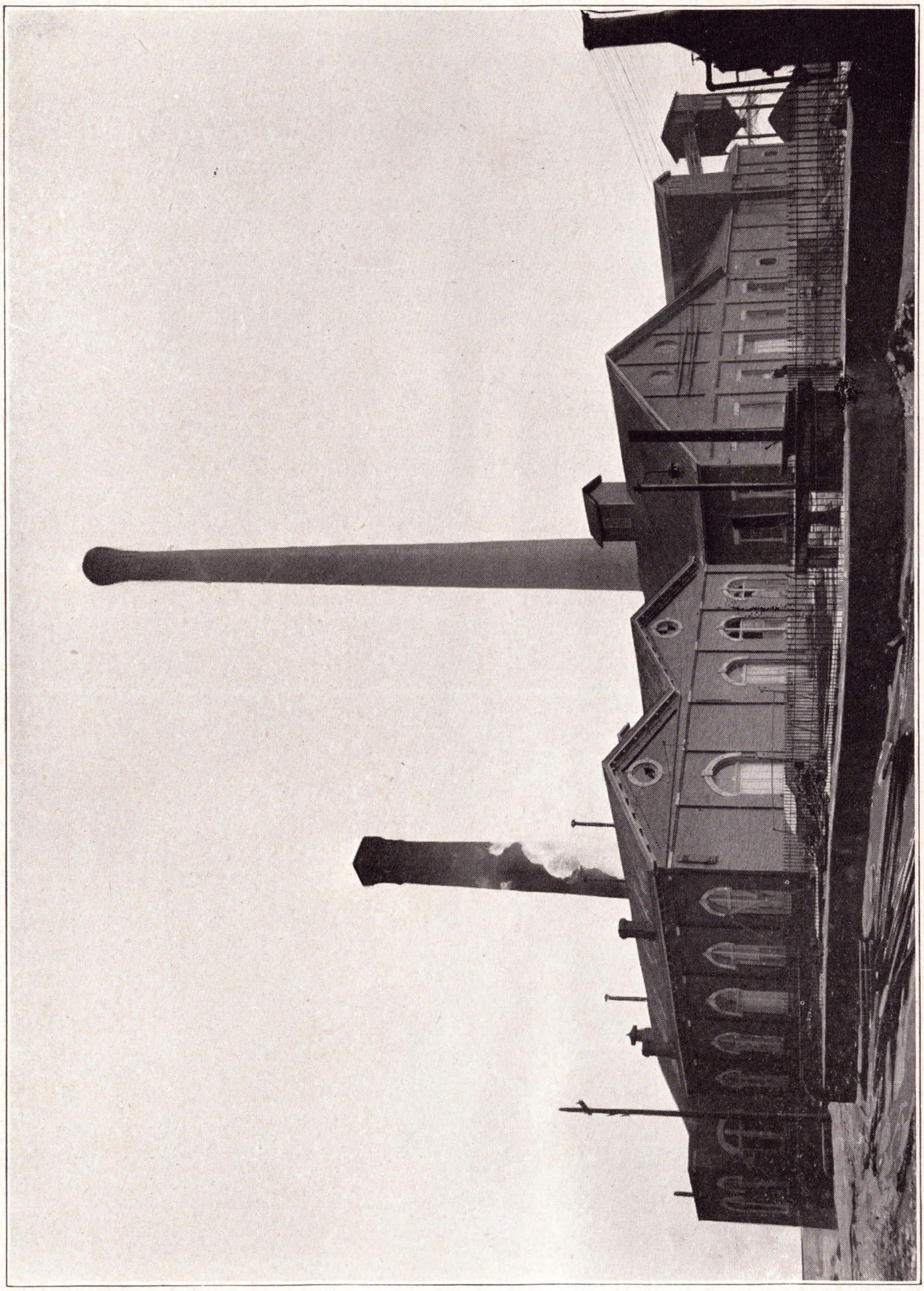
In a boiler test the temperature of the feed water is usually something less than 212° F., and the steam pressure is commonly higher than zero, gage. In the test outlined previously, the feed-water temperature was 180° F. and the pressure was 100 pounds per square inch, gage. It must be clear, then, that the amount of heat required to change a pound of water at 180° to steam at 100 pounds gage pressure is not the same as to make a pound of steam from and at 212° F.

To make allowance for the difference in temperature and pressure, the actual evaporation must be multiplied by a number called the "factor of evaporation." The factor of evaporation has a certain value corresponding to every feed-water temperature and boiler pressure, and the values of this factor are given in the accompanying table. Along the top of the table are given the gage pressures of the steam. In the columns at the sides of the table are given the feed-water temperatures. To find the factor of evaporation for a given set of conditions, locate the gage pressure at the top of the table and follow down that column to the horizontal line on which the feed-water temperature is located. The value in this column and on the horizontal line thus found is the factor of evaporation required. If the feed water has a temperature greater than 212° F., obtain the proper factor of evaporation from the Marks and Davis steam tables.

Take the data of the test, for example. The average steam pressure is 100 pounds, gage. The average feed-water temperature is 180° F. So, in the table locate the column headed 100 and follow down this column to the line having 180 at the ends, and the value where the column and the line cross is 1.0727, which is the factor of evaporation for a feed-water temperature of 180° F. and a steam pressure of 100 pounds, gage.

This factor, 1.0727, indicates that to change a pound of water at 180° F. to steam at 100 pounds requires 1.0727 times as much heat as to change a pound of water at 212° F. to steam at atmospheric pressure. In other words, the heat used in producing an actual evaporation of 7 pounds under the test conditions would have evaporated $7 \times 1.0727 = 7.5$ pounds from and at 212° F. Hence, 7.5 pounds is called the "equivalent evaporation from and at 212° F." per pound of coal used.

As already stated, it takes 970.4 B. t. u. to make a pound of steam from and at 212° F. Then to make 7.5 pounds there would be required $7.5 \times 970.4 = 7{,}278$ B. t. u. This is the amount



Municipal Plant City of Logansport, Indiana, Equipped with C-H Water Tube Boilers of heat required to change 7.5 pounds of water at 212° F. to steam at zero gage pressure, but it is also the heat required to change 7 pounds of water at 180° F. to steam at 100 pounds gage pressure, because 7.5 pounds from and at 212° F. is equivalent to 7 pounds from 180° F. to steam at 100 pounds. Therefore, the 7,278 B. t. u. is the amount of heat usefully employed in making steam per pound of coal fired, and so it is the OUTPUT. Accordingly, the efficiency of the boiler is—

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{7{,}278}{13{,}500} = 0.54, \text{ nearly.}$$

In other words, the efficiency of the boiler is 0.54, or 54 per cent, which means that only a little more than half of the heat in the coal is usefully employed in making steam.

The chart shown in Figure 3 is given to save the work of figuring the efficiency. If the equivalent evaporation per pound of coal is calculated and the heating value of the coal is known, the boiler efficiency may be found directly from the chart. At the left-hand side locate the point corresponding to the equivalent evaporation and at the bottom locate the point corresponding to the heating value of the coal. Follow the horizontal and vertical lines from these two points until they cross, and note the diagonal line that is nearest to the crossing point. The figures marked on the diagonal line indicate the boiler efficiency.

Take the case just worked out, for example. The equivalent evaporation is 7.5 pounds and the heating value of the fuel is 13,500 B. t. u. At the left of the chart locate the point 7.5 midway between 7 and 8 and at the bottom locate the point 13,500 midway between 13,000 and 14,000. Then follow the horizontal and vertical lines from these two points until they cross, as indicated by the dotted lines. The crossing point lies on the diagonal corresponding to 54, and so the efficiency is 54 per cent.

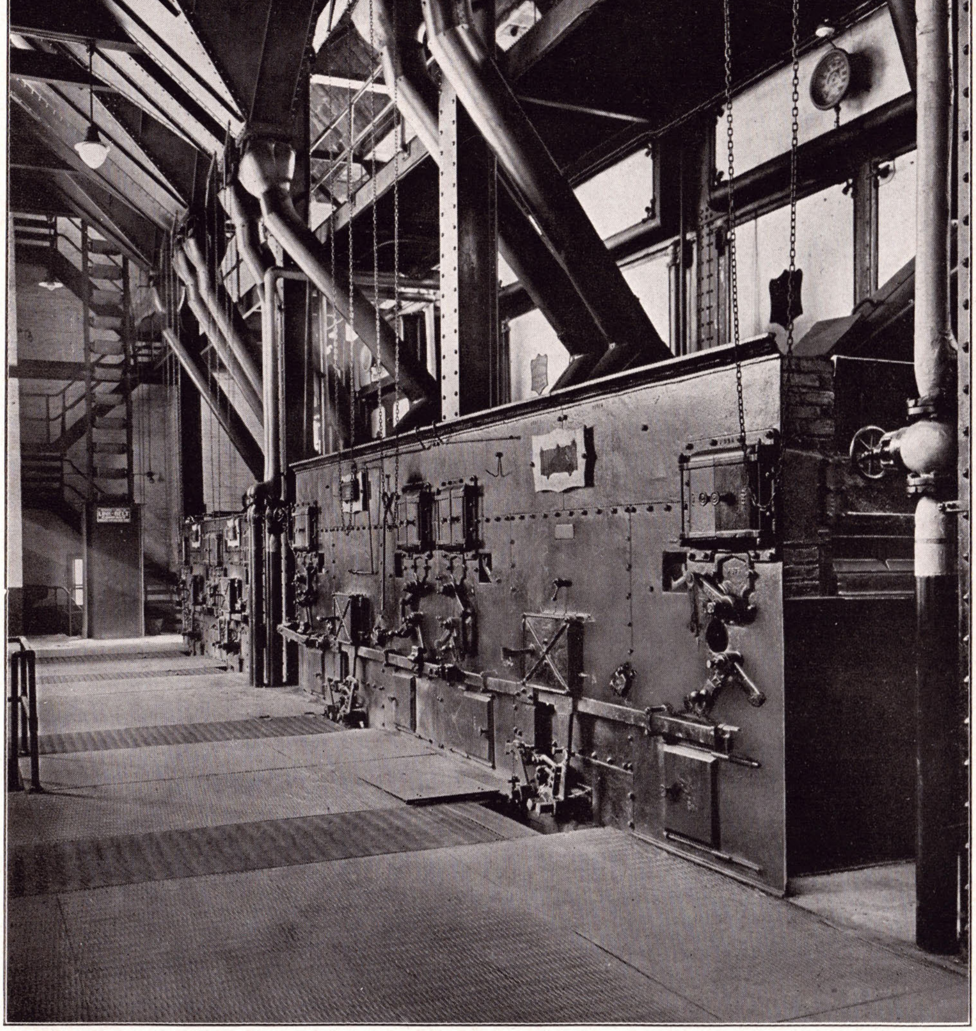
BOILER HORSEPOWER OR CAPACITY

The capacity of a boiler is usually stated in boiler horsepower. A boiler horsepower means the evaporation of 34.5 pounds of water per hour from and at 212° F. Therefore, to find the boiler horsepower developed during a test, calculate the evaporation from and at 212° F. per hour and divide it by 34.5.

Take the test previously mentioned, for example. The evaporation from and at 212° F. or the equivalent evaporation, was 7.5 pounds of water per pound of coal. The weight of coal burned per hour was $5{,}000 \div 10 = 500$ pounds. Then the equivalent evaporation was $7.5 \times 500 = 3{,}750$ pounds per hour. According to the foregoing definition of a boiler horsepower, then—

$$\text{Boiler horsepower} = \frac{3{,}750}{34.5} = 109.$$

The "rated horsepower" of a boiler, or the "builders' rating," is the number of square feet of heating surface in the boiler divided by a number. In the case of stationary boilers this number



One of Chicago's Largest Schools Equipped with two 400 H.P. C-H Horizontal Water Tube Boilers is 10 or 12, but 10 is very commonly taken as the amount of heating surface per horsepower. Assuming this value and assuming further that the boiler tested had 1,500 square feet of heating surface, its rated horsepower would be $1{,}500 \div 10 = 150$ boiler horsepower.

It is often desirable to know what per cent of the rated capacity is developed in a test. This is found by dividing the horsepower developed during the test by the builders' rating. In the case of the boiler tested, 109 horsepower was developed. The percentage of rated capacity developed, therefore, was $109 \div 150 = 0.73$, or 73 per cent.

HEATING SURFACE

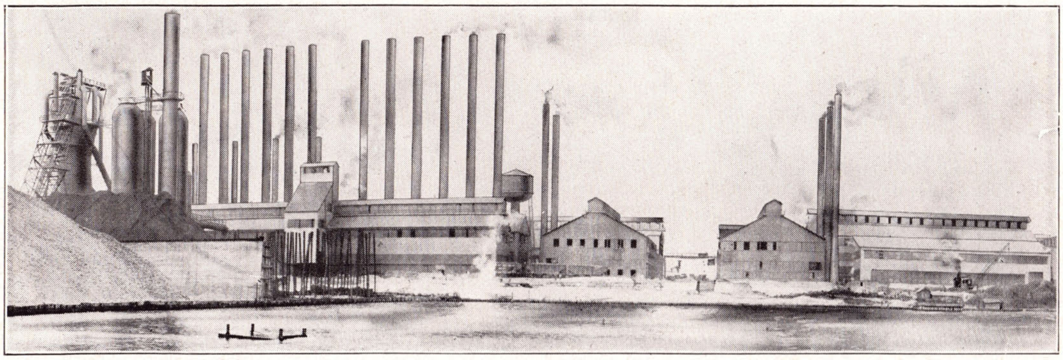
The heating surface of a boiler is the surface of metal exposed to the fire or hot gases on one side and to water on the other side. Thus, the internal surface of the tubes of a fire-tube boiler is the heating surface of the tubes, but the outside surface of the tubes of a water-tube boiler is the heating surface of those tubes. In addition to the tubes, all other surfaces which have hot gases on one side and water on the other must be taken into account. For instance, in a fire-tube boiler from one-half to two-thirds of the shell (depending on how the boiler is set) acts as heating surface. In addition to this, the surface presented by both heads, below the water level, has to be computed. The heating surface of each head is equal to two-thirds its area minus the total area of the holes cut away to receive the tubes.

COST OF EVAPORATION

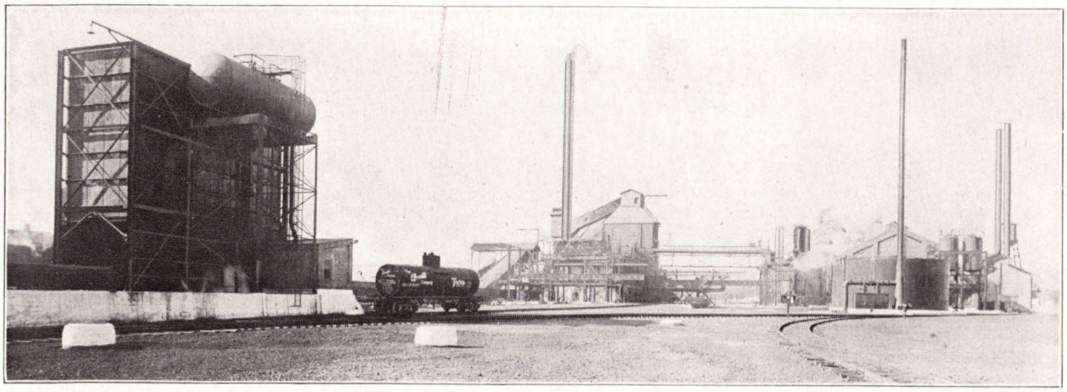
The cost of evaporation is usually stated as the cost of fuel required to evaporate 1,000 pounds of water from and at 212° F. To find it, multiply the price of coal per ton by 1,000 and divide the result by the product of the equivalent evaporation per pound of coal and the number of pounds in a ton.

Suppose that the cost of the coal used in the foregoing test was $3.60 per ton of 2,000 pounds. The equivalent evaporation per pound of coal was 7.5 pounds. Therefore the cost of evaporating 1,000 pounds of water from 180° F. to steam at 100-pound gage, is—

$$\frac{\$3.60 \times 1{,}000}{7.5 \times 2{,}000} = \$0.24, \text{ or 24 cents.}$$



Mark Manufacturing Company, Chicago, Illinois, Equipped with six 600 H.P. C-H Vertical Water Tube Boilers



Gulf States Steel Company Coke Oven and By-products Plant, Gadsden, Alabama, Equipped with two 400 H.P. C-H Horizontal Water Tube Boilers

TABLE OF TEST RESULTS

After the test has been made and properly worked up, as heretofore described, collect all the results of the test on one sheet, so that they can be kept in convenient form for reference and for comparison with later tests. A brief form of arranging the results is as follows:

1.	Date of test		May 20, 1918
2.	Duration of test	hours	10
3.	Weight of coal used	pounds	5,000
4.	Weight of water fed and evaporated	do	35,000
5.	Average steam pressure, gauge	do	100
6.	Average feed-water temperature	°F	180
7.	Factor of evaporation		1,0727
8.	Equivalent evaporation from and at 212° F	pounds	37,545

EFFICIENCY

9.	Efficiency of boiler and furnace	per cent	54

CAPACITY

10.	Boiler horsepower developed		109
11.	Builders' rated horsepower		150
12.	Percentage of rated horsepower developed	per cent	73

ECONOMIC RESULTS

13.	Actual evaporation per pound of coal	pounds	7
14.	Equivalent evaporation from and at 212° F. per pound of coal as fired, pounds		7.5
15.	Cost of coal per ton (2,000 pounds)		$3.60
16.	Cost of coal to evaporate 1,000 pounds from and at 212° F		$0.24

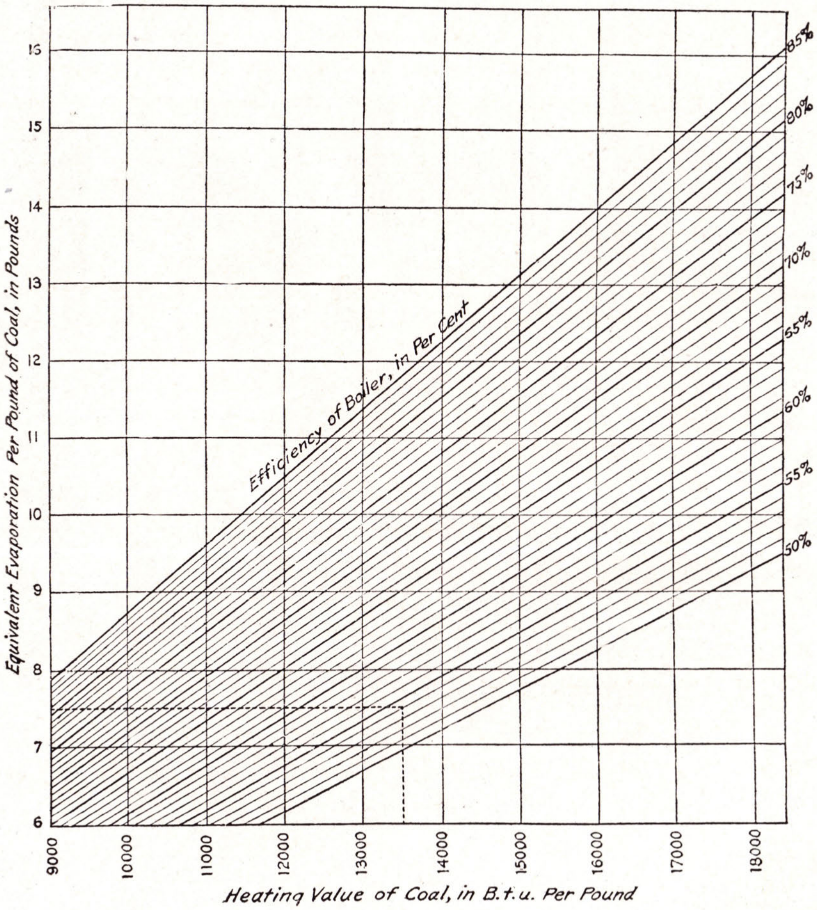
HOW TO USE THE TEST RESULTS

The object of working up a test is to obtain a clear idea as to the efficiency of operation of the boiler or its operating cost. Consequently, after the calculations have been made, they should be used as a basis for study with the idea of improving the boiler performance.

Take the matter of boiler efficiency, for example, as found from the test mentioned. Its value was 54 per cent. This is altogether too low and indicates wasteful operation. The efficiency of a hand-fired boiler ought not to be less than 65 per cent, and it can be increased to 70 per cent by careful management under good conditions.

The chart in Figure 3 can be used to indicate the evaporation that should be obtained in order to reach a desired efficiency. Suppose, for example, that it is desired to know how much water per pound of coal must be evaporated to produce a boiler efficiency of 65 per cent with coal having a heating value of 13,500 B. t. u. per pound.

Locate 13,500 at the bottom of the chart, follow the vertical line until it meets the diagonal marked 65 per cent, and then from this point follow the horizontal line to the left-hand edge, where the Figure 9 is found. This means that the equivalent evaporation from and by 212° F. per pound of coal must be 9 pounds of water. If the steam pressure is 100 pounds gauge, and the feed-water temperature is 180° F. the factor of evaporation is 1.0727, then the actual evaporation must be $9 \div 1.0727 = 8.36$ pounds per pound of coal. In other words, to increase the efficiency from 54 per cent to 65 per cent under the same conditions of pressure and feed-water temperature, it would be necessary to increase the actual evaporation from 7 pounds to 8.36 pounds. This would mean practically 20 per cent more steam from the same weight of coal used.



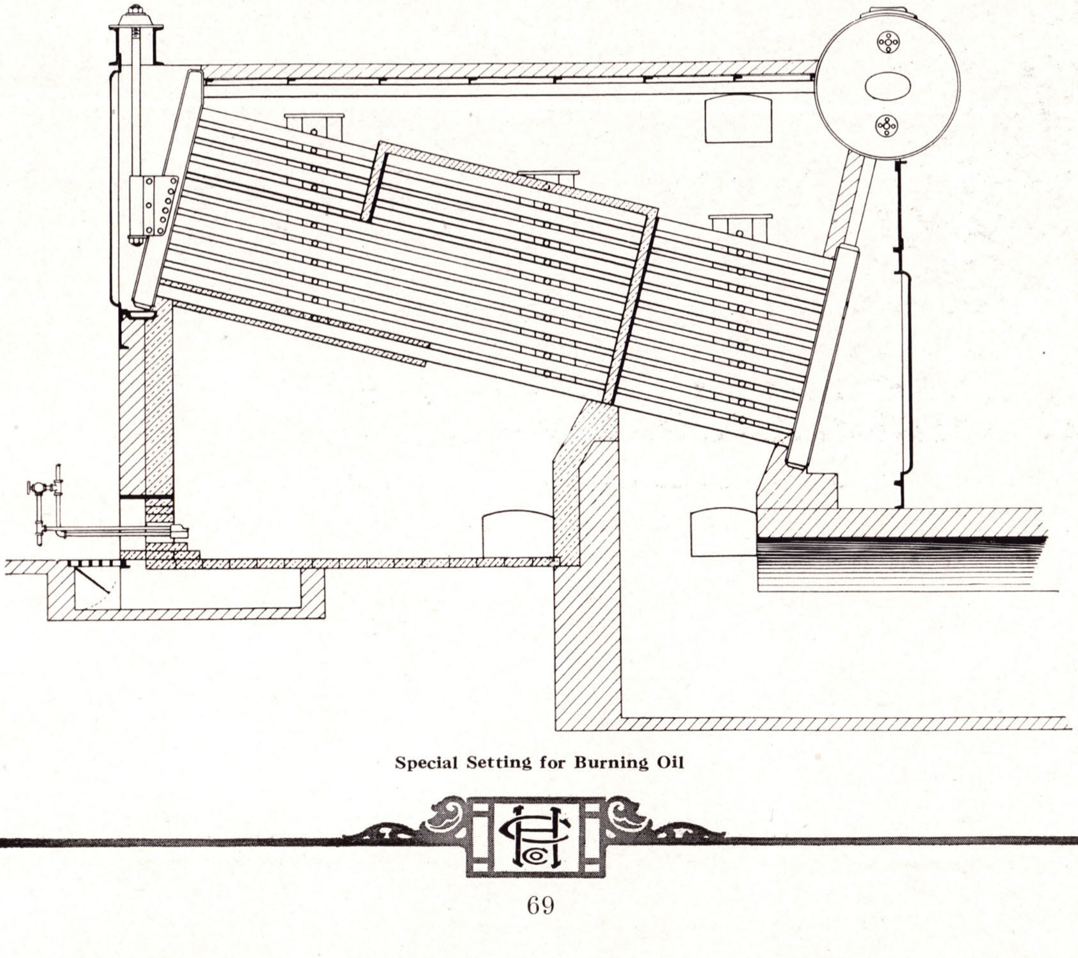
How to do this will require some study and experimenting on the part of the fireman or engineer. The three most common reasons for low-boiler efficiency are (1) excess air, (2) dirty heating surfaces, and (3) loss of coal through the grates. THE FIRST OF THESE ITEMS IS THE MOST IMPORTANT OF THE THREE. In most cases the greatest preventable waste of coal in a boiler plant is directly due to excess air. Excess air simply means the amount of air which gets into the furnace and boiler which is not needed for completing the combustion of the coal. Very often twice as much air is admitted to the boiler setting as is required. This extra or excess air is heated and carries heat out through the chimney instead of heating the water in the boiler to make steam. There are two ways in which this excess air gets into the furnace and boiler setting. First, by a combination of bad regulation of drafts and firing. The chances are your uptake damper is too wide open. Try closing it a little. Then, there may be holes in the fire. Keep these covered. The second way excess air occurs is by leakage through the boiler setting, through cracks in the brickwork, leaks around the frames and edges of cleaning doors, and holes around the blow-off pipes. There are also other places where such air can leak in.

Take a torch or candle and go over the entire surface of your boiler setting—front, back, sides, and top. Where the flame of the torch is drawn inward there is an air leak. Plaster up all air leaks and repair the brickwork around door frames where necessary. You should go over your boiler for air leaks once a month.

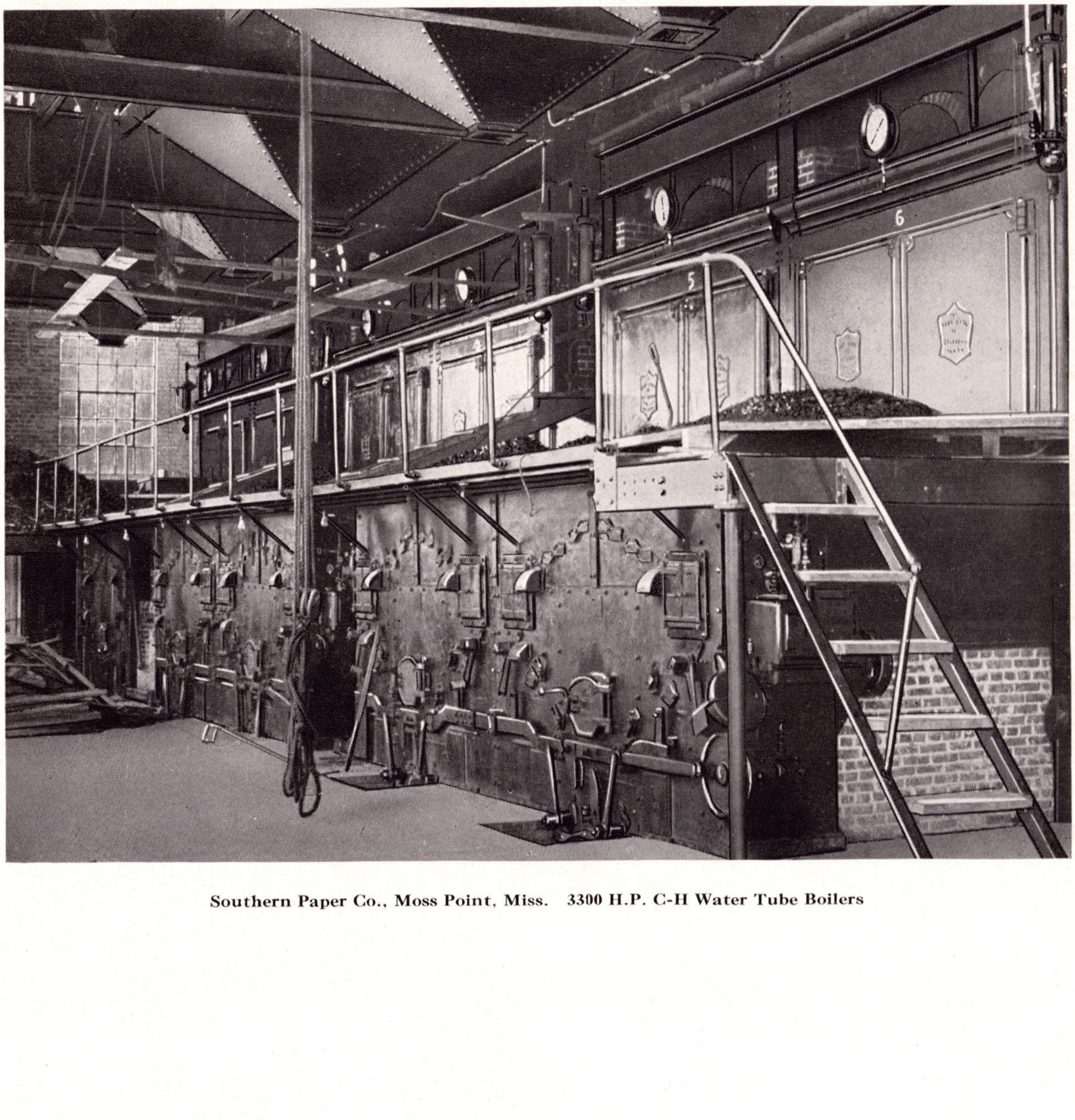
In regard to best methods of firing soft coal, see Technical Paper No. 80 of the Bureau of Mines, which may be obtained from your State Fuel Administrator.

Dirty heating surfaces cause low efficiency because they prevent the heat in the hot gases from getting through into the water. Therefore, keep the shell and tubes free of soot on one side and scale on the other. Soot may be removed by the daily use of blowers, scrapers, and cleaners. The problem of scale and pure feed water is a big one and should be taken up with proper authorities on the subject.

There are many things that may be done to increase the efficiency of the boiler and to save coal. For convenience a number of these points are grouped in the following list:



Special Setting for Burning Oil



Southern Paper Co., Moss Point, Miss. 3300 H.P. C-H Water Tube Boilers

WHAT TO DO	WHY
1. Close up all leaks in the boiler setting.	To prevent waste of heat due to excess air admitted.
2. Keep shell and tubes free from soot and scale.	To allow the heat to pass easily into the water.
3. Use grates suited to the fuel to be burned.	To prevent loss of unburnt coal through air spaces.
4. Fire often, and little at a time.	To obtain uniform conditions and better combustion.
5. Cover all thin spots and keep fire bed level.	To prevent burning holes in bed and admitting excess air.
6. Do not allow clinkers to form on side or bridge walls.	Because they reduce the effective area of the grate.
7. Keep the ash pit free from ashes and hot clinkers.	To prevent warping and burning out of the grates.
8. Do not stir the fire except when necessary.	Because stirring causes clinker and is likely to waste coal.
9. Use damper and not ash-pit doors to control draft.	Because less excess air is admitted by so doing.
10. See that steam pipes and valves are tight.	Because steam leaks waste heat and therefore coal.
11. Keep blow-off valves tight.	Because leaks of hot water waste coal.
12. Cover steam pipes and the tops of boilers.	To prevent radiation and loss of heat.

Make a boiler test under the conditions of operation as they now exist in your plant. Then make all possible improvements as suggested in this bulletin, make another test afterwards and note the increase in the equivalent evaporation per pound of coal used.

Remember that the FIRING LINE in the boiler room can be just as patriotic and helpful as the FIRING LINE at the front.

Boiler and Furnace Testing

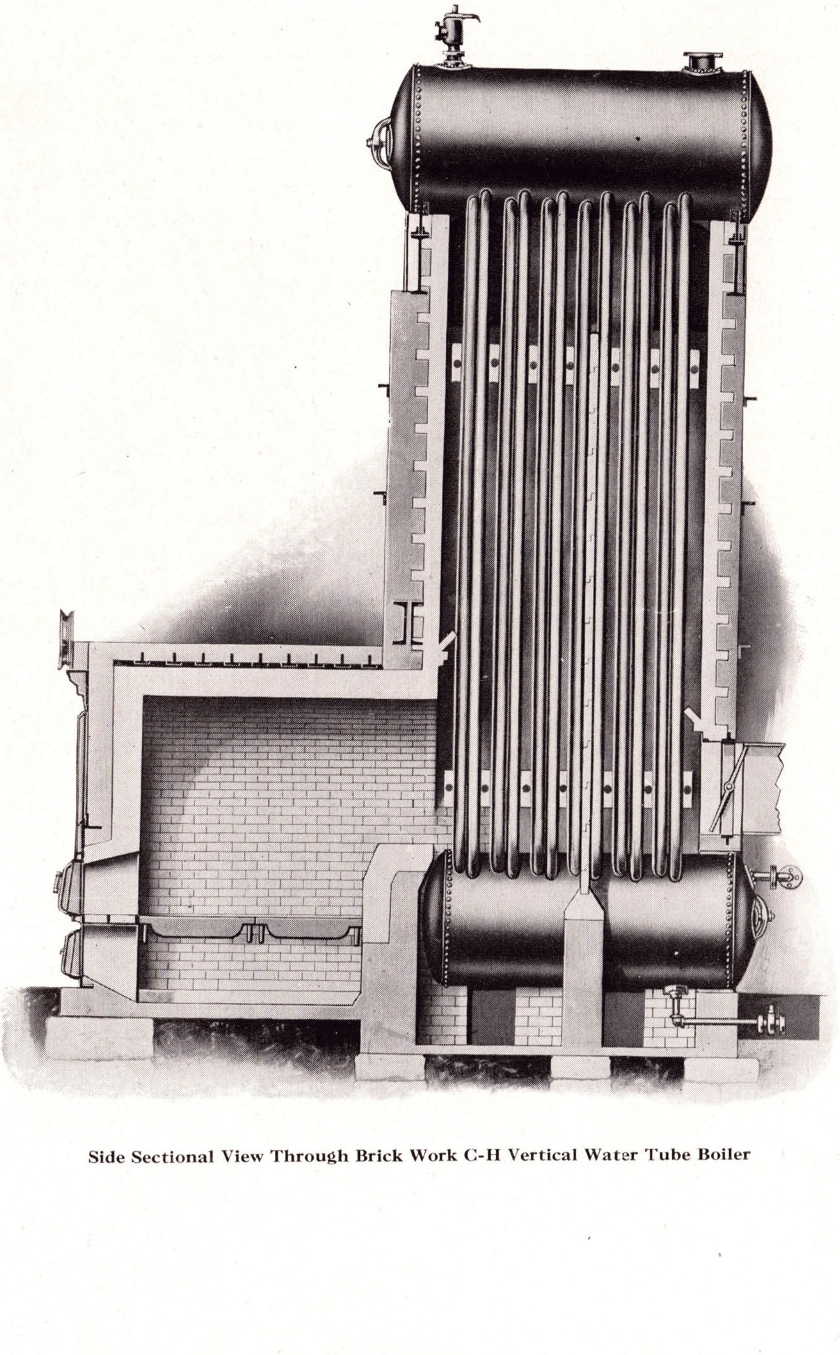
TABLE OF FACTORS OF EVAPORATION

Feed temperature, ° F.	Steam pressure in pounds per square inch, gauge.							
	30	50	70	80	90	100	110	120
32	1.2073	1.2144	1.2195	1.2216	1.2234	1.2251	1.2266	1.2279
35	1.2042	1.2113	1.2164	1.2184	1.2203	1.2219	1.2235	1.2248
38	1.2011	1.2082	1.2133	1.2153	1.2172	1.2188	1.2204	1.2217
41	1.1980	1.2051	1.2102	1.2122	1.2141	1.2157	1.2173	1.2186
44	1.1949	1.2020	1.2071	1.2091	1.2110	1.2126	1.2142	1.2155
47	1.1918	1.1989	1.2040	1.2060	1.2079	1.2095	1.2111	1.2124
50	1.1887	1.1958	1.2009	1.2029	1.2048	1.2064	1.2080	1.2093
53	1.1856	1.1927	1.1978	1.1998	1.2017	1.2033	1.2049	1.2062
56	1.1825	1.1896	1.1947	1.1967	1.1986	1.2002	1.2018	1.2031
59	1.1794	1.1865	1.1916	1.1937	1.1955	1.1972	1.1987	1.2000
62	1.1763	1.1835	1.1885	1.1906	1.1924	1.1941	1.1956	1.1970
65	1.1733	1.1804	1.1854	1.1875	1.1893	1.1910	1.1925	1.1939
68	1.1702	1.1773	1.1823	1.1844	1.1862	1.1879	1.1894	1.1908
71	1.1671	1.1742	1.1792	1.1813	1.1832	1.1848	1.1864	1.1877
74	1.1640	1.1711	1.1762	1.1782	1.1801	1.1817	1.1833	1.1846
77	1.1609	1.1680	1.1731	1.1751	1.1770	1.1786	1.1802	1.1815
80	1.1578	1.1650	1.1700	1.1721	1.1739	1.1756	1.1771	1.1785
83	1.1548	1.1619	1.1669	1.1690	1.1708	1.1725	1.1740	1.1754
86	1.1518	1.1588	1.1638	1.1659	1.1678	1.1694	1.1710	1.1723
89	1.1486	1.1557	1.1608	1.1628	1.1647	1.1663	1.1679	1.1692
92	1.1455	1.1526	1.1577	1.1597	1.1616	1.1632	1.1648	1.1661
95	1.1424	1.1495	1.1546	1.1566	1.1585	1.1602	1.1617	1.1630
98	1.1393	1.1465	1.1515	1.1536	1.1554	1.1571	1.1586	1.1600
101	1.1363	1.1434	1.1484	1.1505	1.1523	1.1540	1.1555	1.1569
104	1.1332	1.1403	1.1453	1.1474	1.1492	1.1509	1.1525	1.1538
107	1.1301	1.1372	1.1423	1.1443	1.1462	1.1478	1.1494	1.1507
110	1.1270	1.1341	1.1392	1.1412	1.1431	1.1447	1.1463	1.1476
113	1.1239	1.1310	1.1360	1.1382	1.1400	1.1417	1.1432	1.1445
116	1.1209	1.1280	1.1330	1.1351	1.1369	1.1386	1.1401	1.1415
119	1.1178	1.1249	1.1299	1.1320	1.1339	1.1355	1.1370	1.1384
122	1.1147	1.1218	1.1269	1.1289	1.1308	1.1324	1.1340	1.1353
125	1.1116	1.1187	1.1238	1.1258	1.1277	1.1293	1.1309	1.1322
128	1.1085	1.1156	1.1207	1.1227	1.1246	1.1262	1.1278	1.1291
131	1.1054	1.1125	1.1176	1.1197	1.1215	1.1232	1.1247	1.1260
134	1.1023	1.1095	1.1145	1.1166	1.1184	1.1201	1.1216	1.1230
137	1.0993	1.1064	1.1114	1.1135	1.1153	1.1170	1.1185	1.1199
140	1.0962	1.1033	1.1083	1.1104	1.1123	1.1139	1.1154	1.1168
143	1.0931	1.1002	1.1052	1.1073	1.1092	1.1108	1.1124	1.1137
146	1.0900	1.0971	1.1022	1.1042	1.1061	1.1077	1.1093	1.1106
149	1.0869	1.0940	1.0991	1.1011	1.1030	1.1046	1.1062	1.1075
152	1.0838	1.0909	1.0960	1.0980	1.0999	1.1015	1.1031	1.1044
155	1.0807	1.0878	1.0929	1.0950	1.0968	1.0985	1.1000	1.1013
158	1.0776	1.0847	1.0898	1.0919	1.0937	1.0954	1.0969	1.0982
161	1.0745	1.0817	1.0867	1.0888	1.0906	1.0923	1.0938	1.0952
164	1.0715	1.0786	1.0836	1.0857	1.0875	1.0892	1.0907	1.0921
167	1.0684	1.0755	1.0805	1.0826	1.0844	1.0861	1.0876	1.0890
170	1.0653	1.0724	1.0774	1.0795	1.0813	1.0830	1.0845	1.0859
172	1.0632	1.0703	1.0754	1.0774	1.0793	1.0809	1.0825	1.0838
174	1.0611	1.0683	1.0733	1.0754	1.0772	1.0789	1.0804	1.0817
176	1.0591	1.0662	1.0712	1.0733	1.0752	1.0768	1.0783	1.0797
178	1.0570	1.0641	1.0692	1.0712	1.0731	1.0747	1.0763	1.0776
180	1.0549	1.0621	1.0671	1.0692	1.0710	1.0727	1.0742	1.0756
182	1.0529	1.0600	1.0650	1.0671	1.0690	1.0706	1.0721	1.0735
184	1.0508	1.0579	1.0630	1.0650	1.0669	1.0685	1.0701	1.0714
186	1.0488	1.0559	1.0609	1.0630	1.0648	1.0665	1.0680	1.0694
188	1.0467	1.0538	1.0588	1.0609	1.0628	1.0644	1.0660	1.0673
190	1.0446	1.0517	1.0568	1.0588	1.0607	1.0623	1.0639	1.0652
192	1.0425	1.0497	1.0547	1.0568	1.0586	1.0603	1.0618	1.0632
194	1.0405	1.0476	1.0526	1.0547	1.0566	1.0582	1.0597	1.0611
196	1.0384	1.0455	1.0506	1.0526	1.0545	1.0561	1.0577	1.0590
198	1.0363	1.0435	1.0485	1.0506	1.0524	1.0541	1.0556	1.0570
200	1.0343	1.0414	1.0464	1.0485	1.0504	1.0520	1.0535	1.0549
202	1.0322	1.0393	1.0444	1.0464	1.0483	1.0499	1.0515	1.0528
204	1.0301	1.0372	1.0423	1.0444	1.0462	1.0479	1.0494	1.0507
206	1.0281	1.0352	1.0402	1.0423	1.0441	1.0458	1.0473	1.0487
208	1.0260	1.0331	1.0381	1.0402	1.0421	1.0437	1.0453	1.0466
210	1.0239	1.0310	1.0361	1.0381	1.0400	1.0416	1.0432	1.0445
212	1.0218	1.0290	1.0340	1.0361	1.0379	1.0396	1.0411	1.0425

Boiler and Furnace Testing

TABLE OF FACTORS OF EVAPORATION—Concluded

Feed temperature, ° F.	Steam pressure in pounds per square inch, gauge							
	130	140	150	160	170	180	190	200
32	1.2292	1.2304	1.2315	1.2324	1.2333	1.2342	1.2351	1.2358
35	1.2261	1.2273	1.2283	1.2293	1.2302	1.2311	1.2320	1.2327
38	1.2230	1.2242	1.2252	1.2262	1.2271	1.2280	1.2288	1.2296
41	1.2199	1.2211	1.2221	1.2231	1.2240	1.2249	1.2257	1.2265
44	1.2168	1.2180	1.2190	1.2200	1.2209	1.2218	1.2226	1.2234
47	1.2137	1.2149	1.2159	1.2168	1.2178	1.2187	1.2195	1.2202
50	1.2106	1.2118	1.2128	1.2137	1.2147	1.2156	1.2164	1.2171
53	1.2075	1.2087	1.2097	1.2107	1.2116	1.2125	1.2133	1.2141
56	1.2044	1.2056	1.2066	1.2076	1.2085	1.2094	1.2102	1.2110
59	1.2013	1.2025	1.2035	1.2045	1.2054	1.2063	1.2072	1.2079
62	1.1982	1.1994	1.2005	1.2014	1.2023	1.2032	1.2041	1.2048
65	1.1951	1.1963	1.1974	1.1983	1.1992	1.2002	1.2010	1.2017
68	1.1920	1.1933	1.1943	1.1952	1.1961	1.1971	1.1979	1.1986
71	1.1889	1.1902	1.1912	1.1921	1.1931	1.1940	1.1948	1.1955
74	1.1859	1.1871	1.1881	1.1890	1.1900	1.1909	1.1917	1.1924
77	1.1828	1.1840	1.1850	1.1860	1.1869	1.1878	1.1886	1.1894
80	1.1797	1.1809	1.1820	1.1829	1.1838	1.1847	1.1856	1.1863
83	1.1766	1.1778	1.1789	1.1798	1.1807	1.1817	1.1825	1.1832
86	1.1735	1.1748	1.1758	1.1767	1.1776	1.1786	1.1794	1.1801
89	1.1704	1.1717	1.1727	1.1736	1.1746	1.1755	1.1763	1.1770
92	1.1674	1.1686	1.1696	1.1705	1.1715	1.1724	1.1732	1.1739
95	1.1643	1.1655	1.1665	1.1675	1.1684	1.1693	1.1701	1.1709
98	1.1612	1.1624	1.1635	1.1644	1.1653	1.1662	1.1671	1.1678
101	1.1581	1.1593	1.1604	1.1613	1.1622	1.1632	1.1640	1.1647
104	1.1550	1.1563	1.1573	1.1582	1.1592	1.1601	1.1609	1.1616
107	1.1519	1.1532	1.1542	1.1551	1.1561	1.1570	1.1578	1.1585
110	1.1489	1.1501	1.1511	1.1521	1.1530	1.1539	1.1547	1.1555
113	1.1458	1.1470	1.1481	1.1490	1.1499	1.1508	1.1515	1.1524
116	1.1427	1.1439	1.1450	1.1459	1.1468	1.1478	1.1486	1.1493
119	1.1396	1.1409	1.1419	1.1428	1.1437	1.1447	1.1455	1.1462
122	1.1365	1.1378	1.1388	1.1397	1.1407	1.1416	1.1424	1.1431
125	1.1335	1.1347	1.1357	1.1366	1.1376	1.1385	1.1393	1.1400
128	1.1304	1.1316	1.1326	1.1336	1.1345	1.1354	1.1362	1.1370
131	1.1273	1.1285	1.1295	1.1305	1.1314	1.1323	1.1332	1.1339
134	1.1242	1.1254	1.1265	1.1274	1.1283	1.1292	1.1301	1.1308
137	1.1211	1.1224	1.1234	1.1243	1.1252	1.1262	1.1270	1.1277
140	1.1180	1.1193	1.1203	1.1212	1.1221	1.1231	1.1239	1.1246
143	1.1149	1.1162	1.1172	1.1181	1.1191	1.1200	1.1208	1.1215
146	1.1119	1.1131	1.1141	1.1150	1.1160	1.1169	1.1177	1.1184
149	1.1088	1.1100	1.1110	1.1120	1.1129	1.1138	1.1146	1.1154
152	1.1057	1.1069	1.1079	1.1089	1.1098	1.1107	1.1115	1.1123
155	1.1026	1.1038	1.1048	1.1058	1.1067	1.1076	1.1085	1.1092
158	1.0995	1.1007	1.1018	1.1027	1.1036	1.1045	1.1054	1.1061
161	1.0964	1.0976	1.0987	1.0996	1.1005	1.1014	1.1023	1.1030
164	1.0933	1.0945	1.0956	1.0965	1.0974	1.0984	1.0992	1.0999
167	1.0902	1.0914	1.0925	1.0934	1.0943	1.0953	1.0961	1.0968
170	1.0871	1.0883	1.0894	1.0903	1.0912	1.0922	1.0930	1.0937
172	1.0850	1.0863	1.0873	1.0882	1.0892	1.0901	1.0909	1.0916
174	1.0830	1.0842	1.0853	1.0862	1.0871	1.0880	1.0889	1.0896
176	1.0809	1.0822	1.0832	1.0841	1.0850	1.0860	1.0868	1.0875
178	1.0789	1.0801	1.0811	1.0820	1.0830	1.0839	1.0847	1.0354
180	1.0768	1.0780	1.0791	1.0800	1.0809	1.0818	1.0827	1.0834
182	1.0747	1.0760	1.0770	1.0779	1.0788	1.0798	1.0806	1.0813
184	1.0727	1.0739	1.0749	1.0759	1.0768	1.0777	1.0785	1.0793
186	1.0706	1.0718	1.0729	1.0738	1.0747	1.0756	1.0765	1.0772
188	1.0685	1.0698	1.0708	1.0717	1.0727	1.0736	1.0744	1.0751
190	1.0665	1.0677	1.0687	1.0697	1.0706	1.0715	1.0723	1.0731
192	1.0644	1.0656	1.0667	1.0676	1.0685	1.0694	1.0703	1.0710
194	1.0623	1.0636	1.0646	1.0655	1.0664	1.0674	1.0682	1.0689
196	1.0603	1.0615	1.0625	1.0635	1.0644	1.0653	1.0661	1.0669
198	1.0582	1.0594	1.0605	1.0614	1.0623	1.0632	1.0641	1.0648
200	1.0561	1.0574	1.0584	1.0593	1.0602	1.0612	1.0620	1.0627
202	1.0541	1.0553	1.0563	1.0572	1.0582	1.0591	1.0599	1.0606
204	1.0520	1.0532	1.0542	1.0552	1.0561	1.0570	1.0579	1.0586
206	1.0499	1.0511	1.0522	1.0531	1.0540	1.0550	1.0558	1.0565
208	1.0478	1.0491	1.0501	1.0510	1.0520	1.0529	1.0537	1.0544
210	1.0458	1.0470	1.0480	1.0490	1.0499	1.0508	1.0516	1.0524
212	1.0437	1.0449	1.0460	1.0469	1.0478	1.0487	1.0496	1.0503



Side Sectional View Through Brick Work C-H Vertical Water Tube Boiler

The C-H Vertical Water Tube Boiler

THE C-H Vertical Water Tube Boiler might be well-called the simplest Vertical Water Tube Boiler. Its phenomenal success as an efficient steam generator from its initial installation reflects more than usual credit on our Engineering Department. We can say without hesitation that the repairs on the C-H Vertical Water Tube Boiler are practically nothing and need not be considered. These boilers have been placed alongside Vertical Boilers of other makes and in every instance the C-H Vertical Water Tube Boiler not only gave better results in efficiency and upkeep, but were considered the "main-stays" of the steam plant. These boilers are in operation in steel mills, twenty-four hours a day through the year at 100% continuous overload and have shown no sign of weakness. In a large sawmill having a total load of 1,500 to 2,000 horsepower, one 500 horsepower C-H Vertical Water Tube Boiler has carried the entire load. We recommend this boiler especially for the following industries:

Sawmills,
Steel Mills,
Blast Furnaces,
Sugar Centrals,
Electric Light Plants,
Cotton Mills,
Oil Mills,
Waste heat services.

GENERAL DESCRIPTION

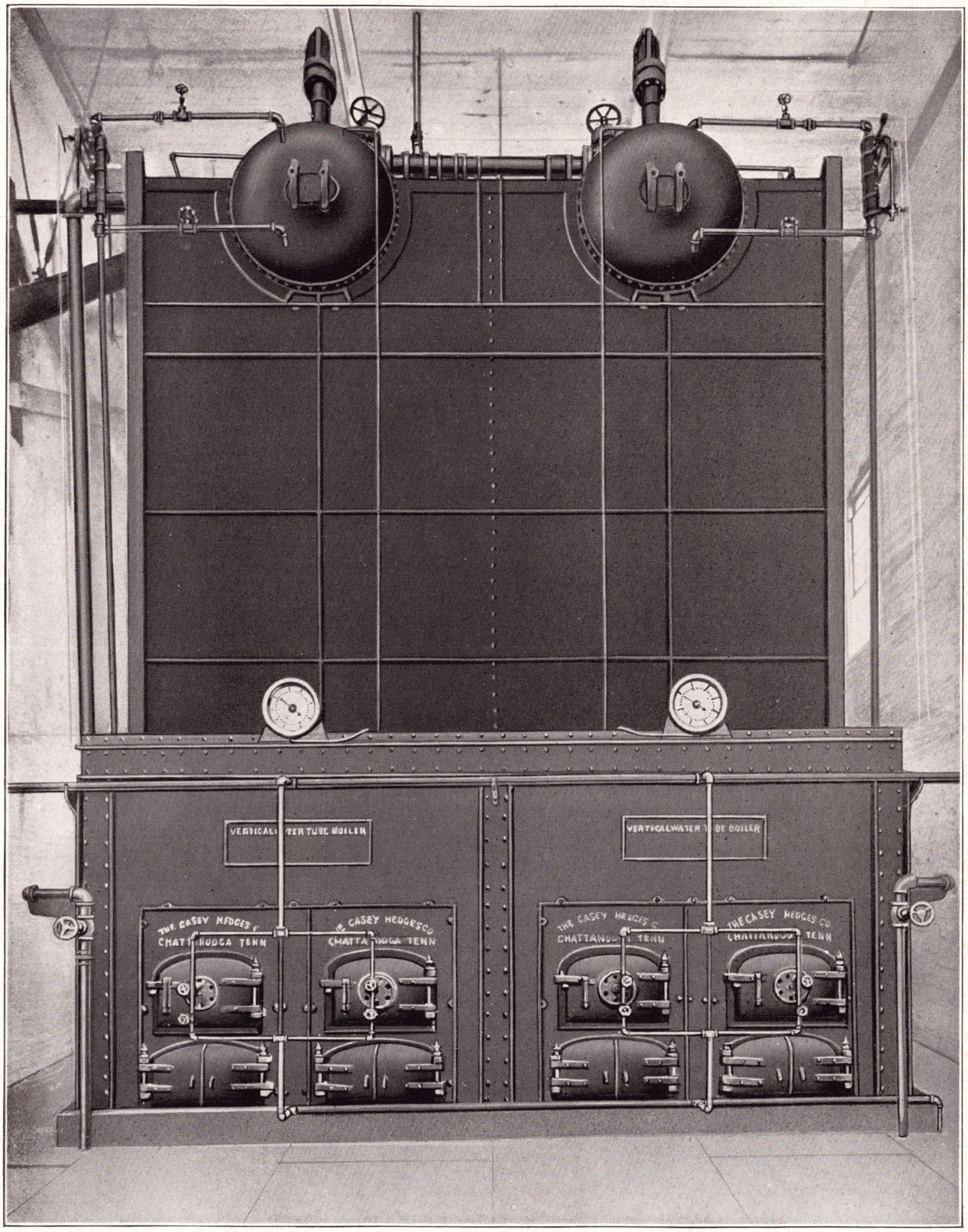
The boiler consists of one or more Upper Drums connected to one or more Lower Drums by a series of tubes placed in staggered rows, to insure all of their surface coming in contact with the products of combustion. Each of the tubes is curved to an easy radius to take care of the expansion and contraction due to the varying temperatures. The tubes enter the drums at right angles with their surfaces and are expanded tightly into place.

The boiler is supported free from the brick work by means of four vertical I beam columns and cross girders. The Upper Drums of the boiler rest on cross girders, and are held in place with steel saddles securely bolted to the cross girders. The vertical columns act as stays to the brick work.

The drums are placed longitudinally with the furance.

The heating surface can be increased in three ways—by adding tubes, by increasing the length of tubes and by adding another sectional unit.

Boilers of over 200 horsepower have two or more Upper and Lower Drums connected together with equalizer tubes and steam connection at top, similar to the Horizontal Water Tube Boiler with double or triple drums, and equalizing drums at the bottom. Any number of drums or units may be connected together to constitute a given horsepower. The size of the boiler is, therefore, unlimited.


VERTICAL WATER TUBE BOILER
VERTICAL WATER TUBE BOILER
THE CASEY HEDGES CO
CHATTANOOGA TENN
THE CASEY HEDGES CO
CHATTANOOGA TENN
THE CASEY HEDGES CO
CHATTANOOGA TENN
THE CASEY HEDGES CO
CHATTANOOGA TENN

Russell-Coleman Cotton Oil Company, San Antonio, Texas. Equipped with C-H Steel Cased Vertical Water Tube Boilers

The Dutch Oven reverberatory furnace at the front of the boiler, on the smaller boilers consists of a single furnace. On the larger boilers, it is made up of multiple furnaces so that the span of the arch is not too great.

It will be noticed that the boiler is baffled vertically. The baffles are placed between one of the nests of tubes in which the tubes are spaced a little farther apart than the others, preventing the baffling from being damaged by the removal of tubes, and it is so constructed that it can be adjusted to suit draft conditions.

The boiler is regularly built with all tubes in place, tested at the factory and made absolutely tight, and is easily erected in position with a frame or jim pole. In a double or multiple drum boiler, it is necessary only to expand the equalizing tubes between drums after the boiler is placed in position.

The success of the Casey-Hedges Vertical Water Tube Boiler is due primarily to the following:

FIRST: The absence of large flat surfaces for tube heads, eliminating entirely stay bolts, handhole plates and gaskets. The drum shells are cylindrical, the most natural shape for a steam container to assume under pressure.

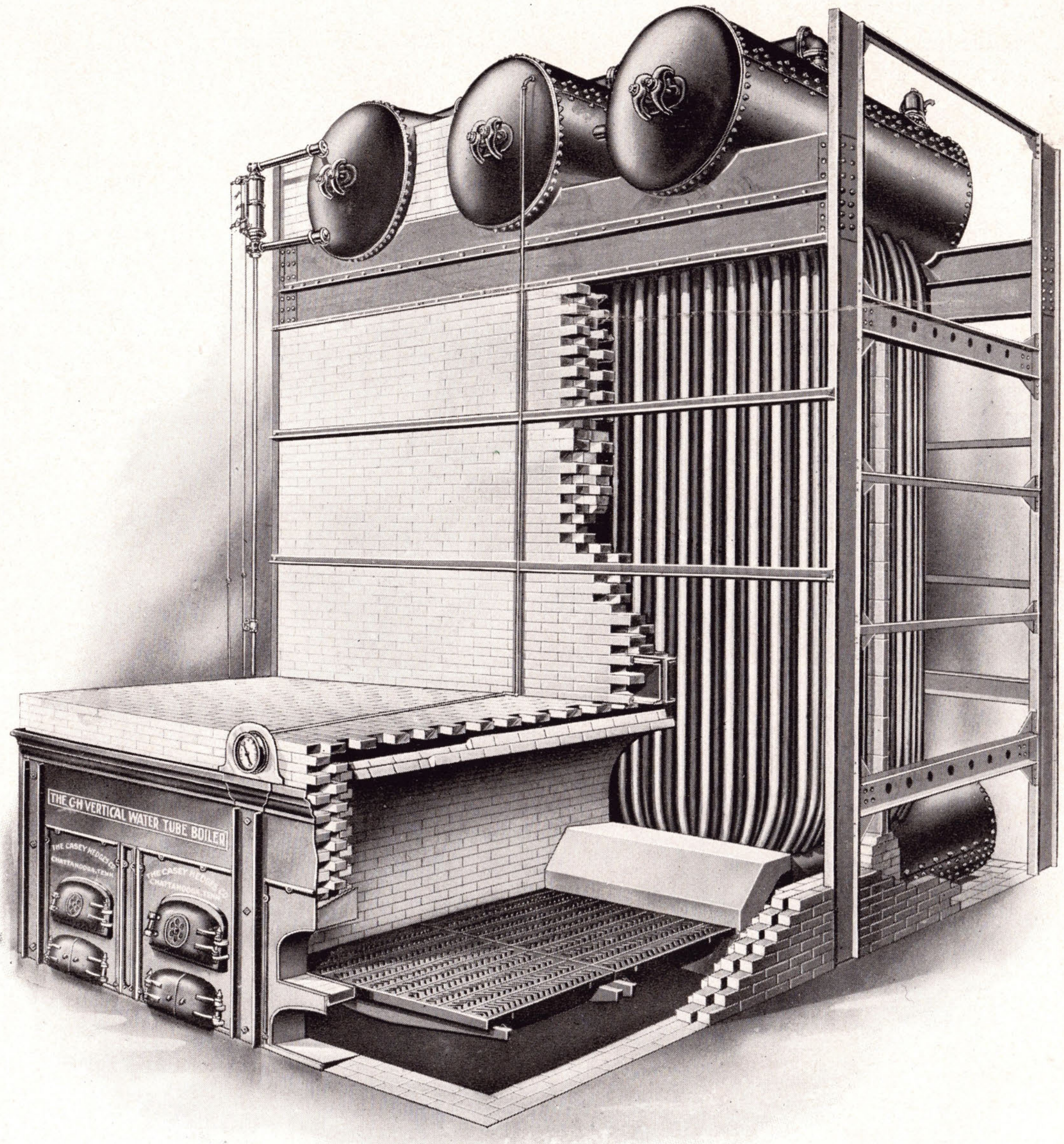
SECOND. The expansion and contraction is admirably taken care of, with properly shaped tubes formed to a radius. Tubes curved to a slight radius are just as easily cleaned with a turbine cleaner as are straight tubes.

THIRD. The Dutch Oven extension and reverberatory furnace, in which complete combustion takes place before the gases are allowed to strike the cooling surfaces of the boiler proper. The Dutch Oven furnace is recommended by all experienced engineers, by the various smoke inspectors in all the large cities, and by a special commission of engineers appointed by the United States Geological Survey to ascertain the best method of burning various fuels.

FOURTH. The notable absence of repairs due to simplicity of construction. Should a tube have to be replaced, it can be easily inserted without taking out or interfering with any other tubes in the boiler. A tube can be taken out and replaced in less time than any other boiler on the market.

FIFTH. Easy cleaning. The occasions to clean the tubes in a Casey-Hedges Vertical Water Tube Boiler are very infrequent, as the rapid circulation prevents the formation of scale. The vertical position of the tubes also tends to shed scale. When it does become necessary to clean the boilers, it can be done in one-third the time it takes to clean boilers of the Horizontal type. It is only necessary to enter the top drum through a single manhole and clean the tubes with a power turbine cleaner. There is ample room for a man to sit comfortably in the top drum and handle the turbine cleaner with ease. The exterior surface of the boiler is practically free from soot; it being next to impossible for soot to adhere to the vertical tubes. Should it accumulate, it can easily be blown from the tubes through the side doors with a steam nozzle soot blower.

SIXTH. ECONOMY IN FUEL CONSUMPTION. The Dutch Oven Furnace and the arrangement of the vertical tubes in staggered rows insure every available heat unit being brought in

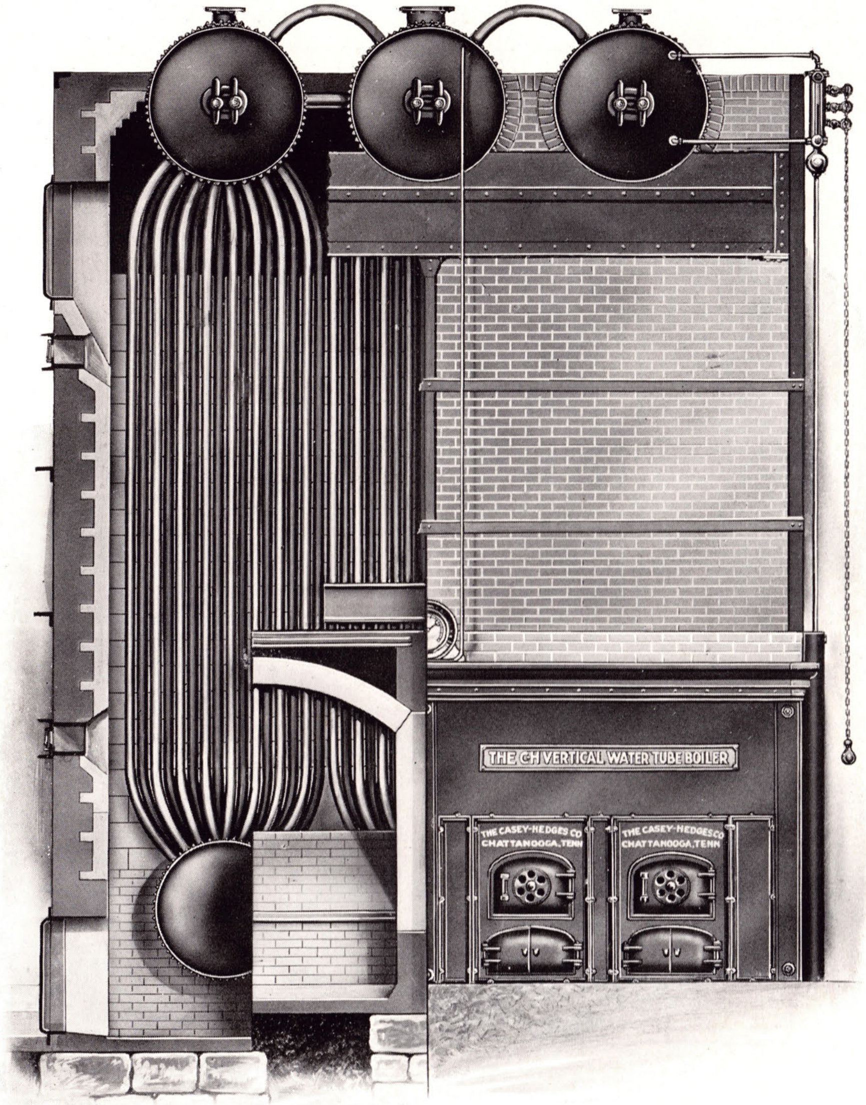

THE C-H VERTICAL WATER TUBE BOILER
THE CASEY HEDGES CO. CHATTANOOGA, TENN.
THE CASEY HEDGES CO. CHATTANOOGA, TENN.

View in Perspective of 500 H.P. Boiler, Showing Brick Work Partially Removed contact with all parts of the tube surface, and this causes a uniform transmission of the heat to the water within them, consequently, the highest degree of efficiency possible.

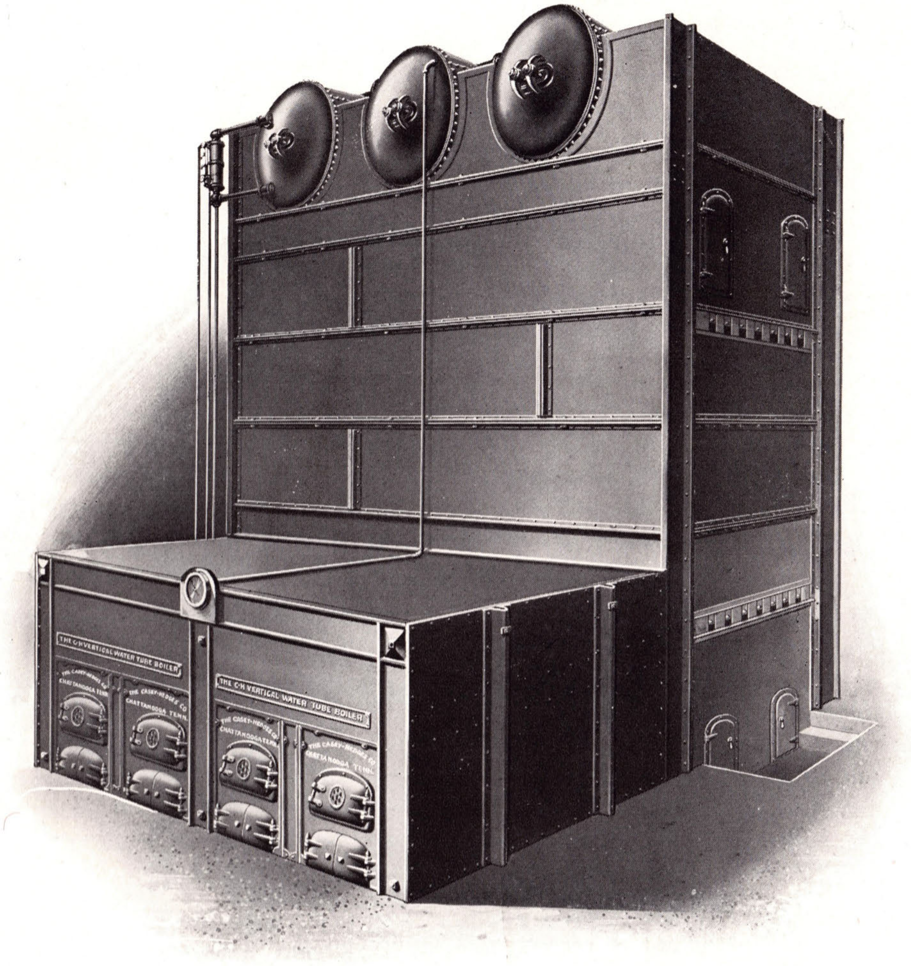
SEVENTH. PERFECT CIRCULATION. The circulation of the Casey-Hedges Vertical Water Tube Boiler might be termed perfection, as it is so nearly so. It will be noticed by referring to the side sectional elevation, that the circulation is positive and the travel of the water is with the gases—the natural way. In the first bank of tubes, in which 75 per cent of the work is done, the circulation of the water is upward from the Lower Drum. Each tube discharges its contents unrestricted into the Upper Drum, liberating the steam globules easily. The water then passes downward into the Lower Drum through the rear bank of tubes. It will be noticed that there are no congested areas through which the water must circulate. Each tube has its own connection to the drums. This construction insures freedom from undue ebullition, and dry steam is delivered when forcing the boiler.

EIGHTH. STOKER ATTACHMENT. Any type of stoker, chain grate, or patented furnace can be used in connection with the Casey-Hedges Vertical Water Tube Boiler, without changing its design.

NINTH. FURNACE MODIFICATIONS. The extension furnace can be designed to suit any class of fuel, such as wet sawdust, bagasse, tan bark, rice chaff and lignite coal. Our Engineering Department is available to our customers and we will furnish designs of furnaces to burn any class of fuel.

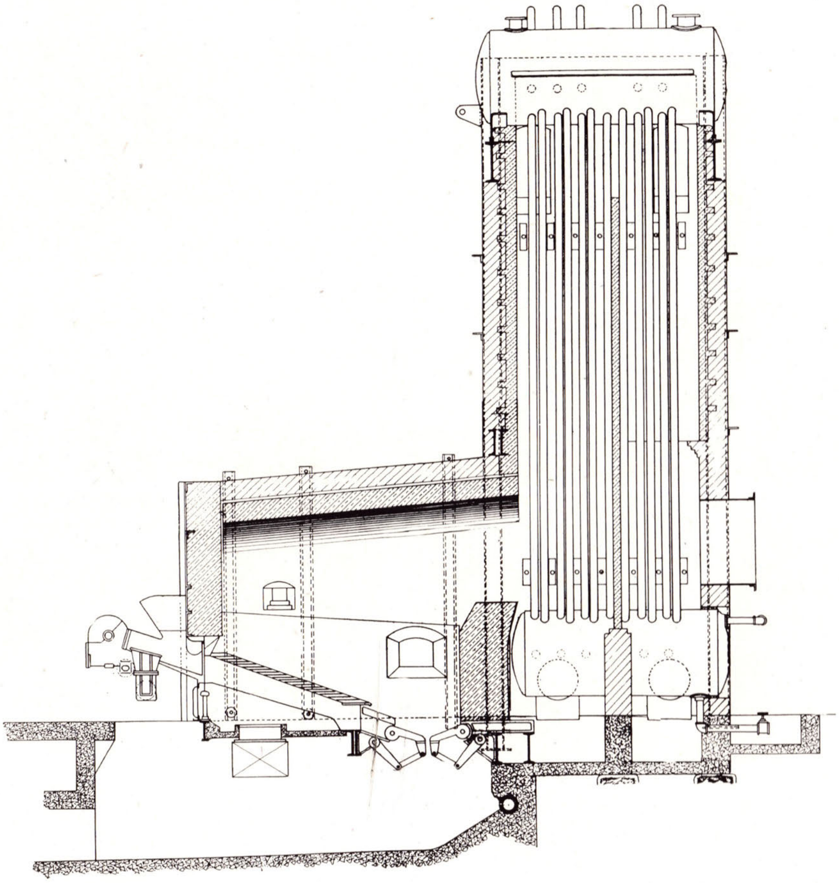

THE C-H VERTICAL WATER TUBE BOILER
THE CASEY-HEDGES CO
CHATTANOOGA, TENN
THE CASEY-HEDGES CO
CHATTANOOGA, TENN

600 H.P. C-H Vertical Water Tube Boiler


THE C-H VERTICAL WATER TUBE BOILER
THE CASEY-HEDGES CO CHATTANOOGA TENN.
THE C-H VERTICAL WATER TUBE BOILER
THE CASEY-HEDGES CO CHATTANOOGA TENN.

C-H Vertical Water Tube Boiler Equipped with Steel Encased Type of Setting

The C-H Vertical Water Tube Boiler makes a very attractive and satisfactory boiler unit when steel encased. The advantages of the Steel Casing are well-known to the Engineering Profession. The Steel Casing is built up of panel shaped sections, reinforced with angles and bolted together. The brick work inside of the Steel Casing is tied into place with anchors and between the brick work and the Steel Casing, there is an asbestos or Sil-o-cel lining. There are no air leakage or radiation losses in the steel encased setting.



C-H Vertical Water Tube Boiler Arranged for Underfeed Type of Stoker

Boiler Settings

THE efficiency of a boiler is influenced largely by the boiler setting. In fact, the term "boiler efficiency" means the efficiency of both the boiler and the setting, therefore, to obtain the highest boiler efficiency it is necessary to have a perfect boiler setting.

Boiler settings are almost universally made of brick. Fire brick are used for the inside courses or the heat zone of the setting and protect the red brick which constitute the balance of the setting from the heat.

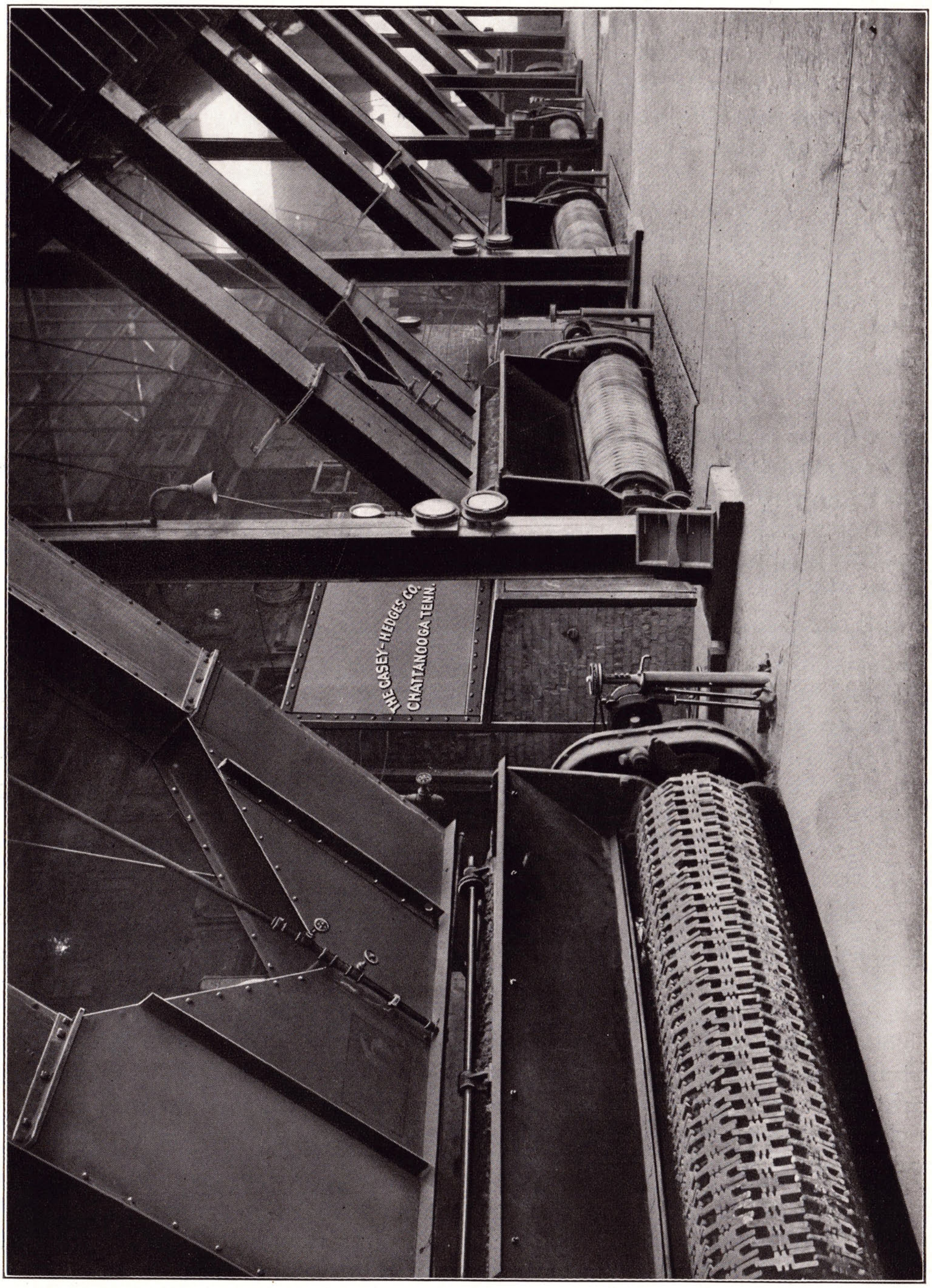
Brick of both kinds should be of good quality. Especial care should be exercised in the selection of fire brick. A high point of plasticity as well as a high fusion point and low element of expansion are very important. Red brick should be of good, hard quality and of uniform size.

A heavy fire in a green boiler setting will cause it to crack. The setting should first be air-dried by opening the boiler damper and the ash pit doors, as soon as the brick work is completed, which will create free circulation of air through the setting. This should continue for several days where practical. When ready for a more thorough drying, build a wood fire in the furnace and heat it gradually until the walls are thoroughly warm, after which coal may be used and the boiler put in service.

Mortar for laying the red brick should consist of one part Portland cement, three parts lime and sixteen parts of clean, sharp sand. Use not less than 2½ bushels of lime per thousand brick. All joints should be thoroughly filled with mortar. Air leaks through the boiler walls are detrimental to efficiency. The fire brick should be dipped in a thin fire clay batter and rubbed and shoved into place, after which they should be driven with a wooden mallet until each brick actually touches the brick below it. The fire clay is not to be used as a binder, but merely to fill all voids between the brick. The fire clay batter should not be sufficiently thick to handle with a trowel. The courses of the fire and the red brick should be laid up together, except in arches, and the fire brick tied into the red brick by means of header courses every fifth course.

Furnace arches should be not less than 9″ thick and made of fire brick or fire clay blocks. As the brick are laid radially in the arch, brick 9″ long will make an arch 9″ thick. The sides of the arches, when the arches form less than one-half of a circle, should have backings made of skew backs. When the arch forms a complete half circle, its sides rest on flat surfaces. Wedge brick or blocks (known as bull head by some manufacturers) are used for making arches. Frequently straight brick have to be used in connection with the arch brick to obtain the radius of arch desired. In such cases the courses of straight brick are interspersed with the courses of wedge brick. Sometimes it is necessary for the wedge courses and sometimes the straight courses to predominate to get the radius desired.

The middle or key course of every arch should be made of wedge brick and should be a close fit. The joints in the arch should be broken. Soap brick or half brick are very convenient for this purpose and should be used at one end of one course and at the opposite end of the ad-


THE CASEY-HEDGES CO.
CHATTANOOGA, TENN.

Six 600 H.P. C-H Vertical Water Tube Boilers Equipped with Chain Grate Stokers in the plant of the Iron and Steel Corporation, Chicago, Illinois joining courses. Arches are built up on wood supports called centers, which have the surface cut to the exact radius of the arches. All brick should fit neatly from top to bottom against the adjoining brick. No thick fire clay joints should be allowed. Dip the brick in a thin fire clay paste and hammer them in position with a wooden mallet. The sides of arches should have solid foundation and solid backing—that is, no voids or mortar pockets which will dry out and crumble should be in the backing or foundation. The surface of the skew backs or foundation on the two sides of the furnace should be exactly parallel. While it is important that all fire brick for boiler furnaces should be of good quality, it is more important that brick for the arches be selected with extreme care. Good arches require brick of practically perfect workmanship. The expansive element of an arch fire brick should be very low. Too much alumina in the brick makes it unsuitable for arches.

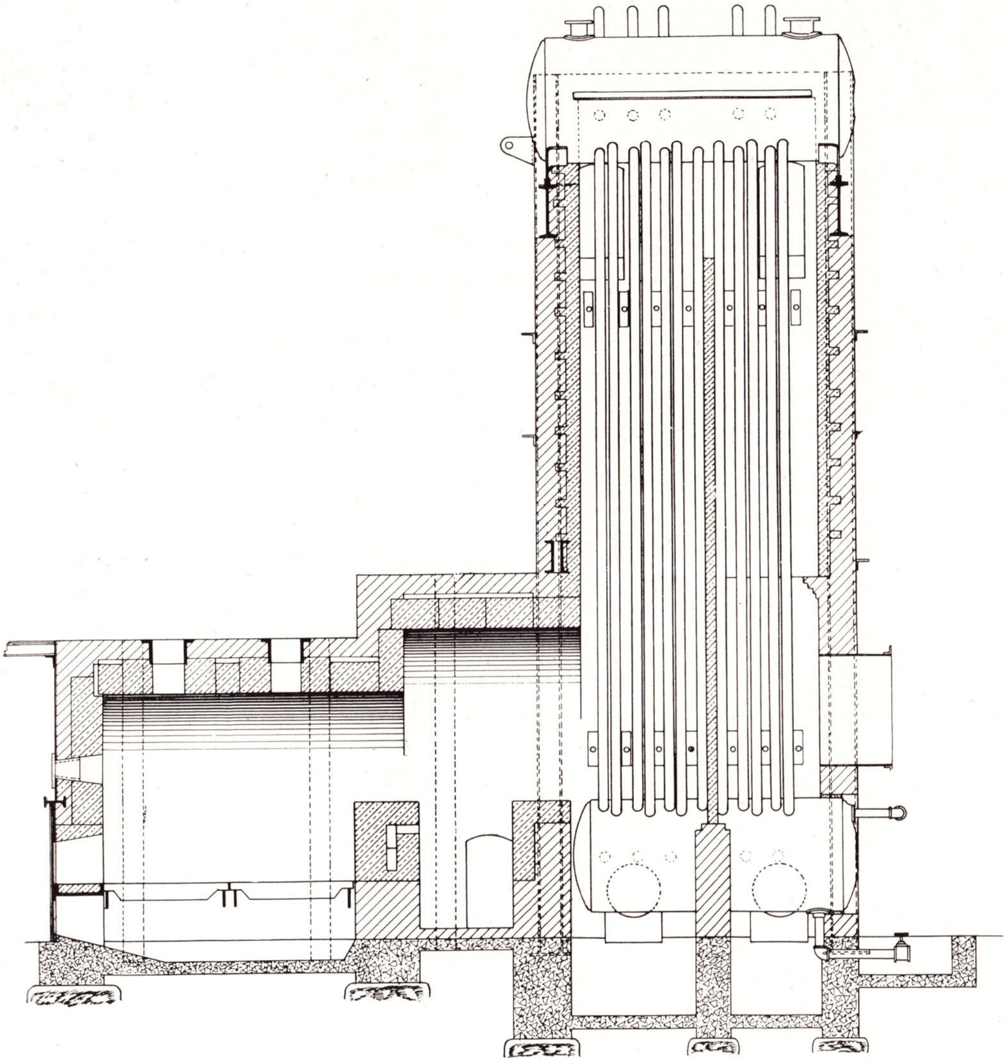
As the brick work progresses, all tie rods for buckstays should be put in place. On completion of the brick work the buckstays should be bolted in place and nuts drawn up tight, after which they should be slightly loosened until the setting is thoroughly dried out, when they are to be tightened. The brick mason should see that there are no gas passages or channels for short circuiting of the gas between the boiler walls and the baffles of the boiler.

The doors for cleaning boiler settings and blowing soot from the settings should be carefully set in the walls and anchored to them, being sure that there are no air leaks around the doors. In the case of soot dusting panels or doors, the holes for inserting the steam lance or soot blowers should register with the spaces between the rows of tubes.

All cleaning doors in the setting should have arches the entire thickness of the wall sprung across them.

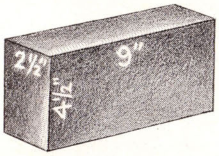
The Casey-Hedges Company furnishes tile door arches as regular equipment for standard fire doors. For special fire doors, cast iron lintel plates or door arches are furnished to suit.

The tops of the drums should be insulated with a rowlock of red brick or a plastic insulating material not less than 2″ thick. When asbestos or 85% magnesia cement is used, it should be laid on to within about ½″ of the thickness required, and then finished over with a mixture of cement and plastic material about ½″ thick. When red brick are used, they should be laid in lime mortar with the joints open at the upper edge, and after all bricks are laid in place, joints should be filled with cement mortar and a coat of cement about ½″ thick should cover the entire surface of the brick.

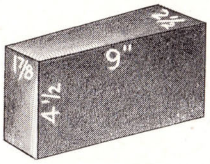


C-H Vertical Water Tube Boiler Arranged with Special Furnace with Combustion Chamber for Burning Sawdust and Refuse Fuel

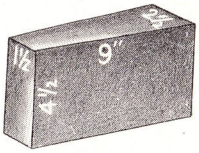
We illustrate below some of the most popular shapes of fire brick. These shapes are standard with all of the leading manufacturers.



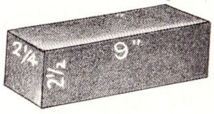
9" STRAIGHT
9" x 4½" x 2½"



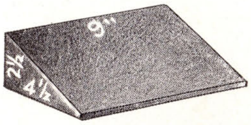
No. 1 WEDGE
9" x 4½" x (2½" — 1⅞")



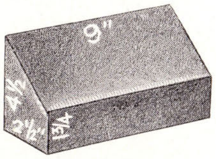
No. 2 WEDGE
9" x 4½" x (2½" — 1½")



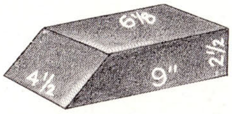
SOAP
9" x 2¼" x 2½"



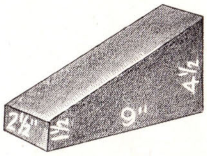
FEATHER EDGE
9" x 4½" x (2½" — ⅛")



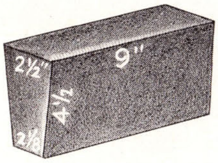
SIDE SKEW
9" x (4½" — 1¾") x 2½"



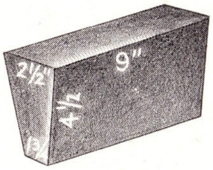
END SKEW
(9" — 6⅛") x 4½" x 2½"



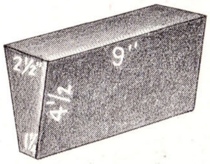
EDGE SKEW
9" x (4½" — 1½") x 2½"



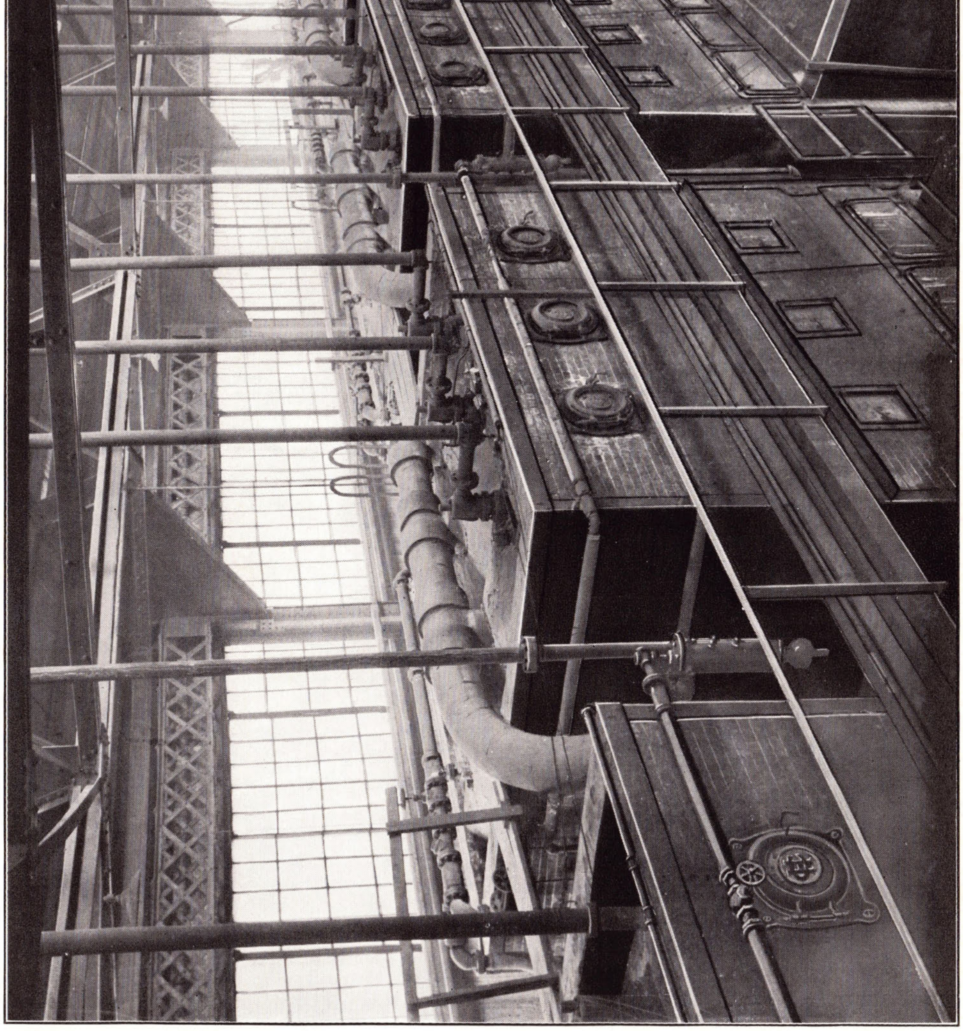
No. 1 ARCH
9" x 4½" x (2½" — 2⅛")



No. 2 ARCH
9" x 4½" x (2½" — 1¾")



No. 3 ARCH
9" x 4½" x (2½" — 1")



Six 650 H.P. Vertical Water Tube Boilers, Four Pass Type

Putting New Boilers in Service

BEFORE putting new boilers in service, examine the boiler setting carefully and see that the baffles are in their proper position, that there are no gas leaks through the baffles and the boiler setting walls, that the bridge walls are of correct height and that the boiler is set at the proper elevation, both front and back.

Examine the boiler internally and see that all baffle plates, dry pipes, mud pans, internal feed pipes, internal blow-off pipes and all other internal fittings are securely held in their proper position.

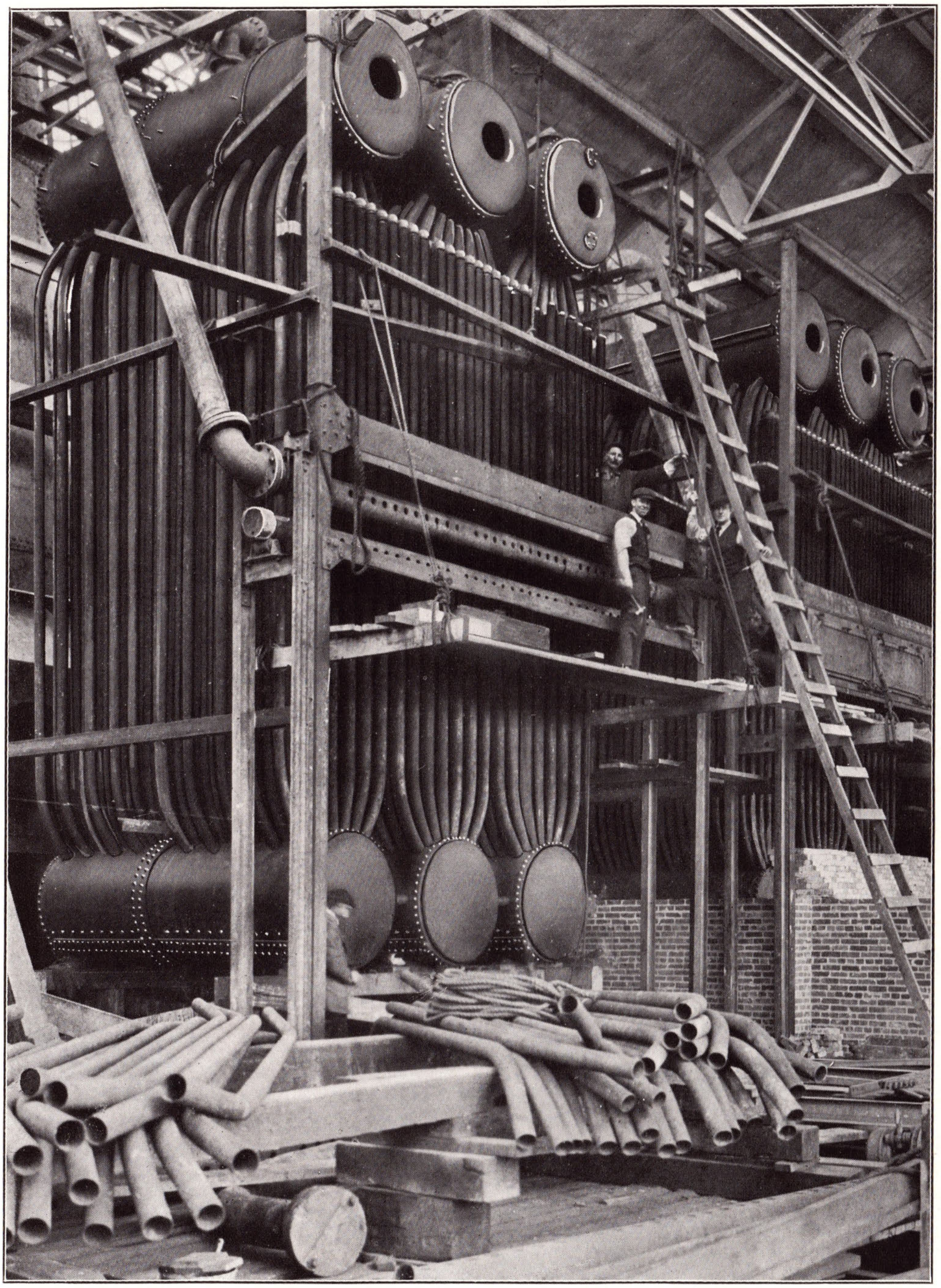
If there is any oil, dirt, waste or other foreign matter in the boiler, it should be removed. To remove oil and grease, put a quantity of soda ash in the boiler, fill it with water to its correct water level and boil it for ten or twelve hours. After the boiler and setting have cooled, empty the boiler and wash it out thoroughly with cool water.

The blow-off pipe should be free to expand and contract without restriction by the brick work. The water column and its connections should be examined to see that it is erected at the correct height and the correct water level will be indicated by the gauge glass and gauge cocks. Lift the lever of the safety valve to be sure that it is not stuck and will blow out at the pressure at which it is set. All pipe connections to the boiler should be well made. In the case of flanged joints, a good gasket should be used and the nuts of all bolts made tight to avoid blowing of gaskets. The safety valve should be bolted directly to the boiler or connected to it with a very short nipple. Do not use a pipe or long nipple. This would cause the safety valve to chatter and it would not register correctly.

BOILER FOUNDATIONS

It is essential that boiler settings rest on solid and level foundations. Usually a concrete bed from 8″ to 12″ deep, with a smooth surface, is sufficient for supporting a boiler setting wall. Under the main boiler supports there should, however, be piers of suitable proportions to sustain the load that will be concentrated on them. The proportions of the piers should be arrived at with due consideration to the load and to the bearing value of the soil, which can be closely determined by a man with experience in such work.

The composition of the concrete should be in a proportion of one part cement, four parts sand and seven parts broken stone or clean gravel. After placing the concrete in the bed it should be rammed until it is so compact that water will appear on the surface. However, too much water should not be used. 35 pounds to each 100 pounds of cement will be ample. The entire foundation up to the floor line can be made of concrete with excellent results, but the concrete can be carried to within a few inches of the floor line and brick used to bring it to the surface if desired. When brick is used below the floor line it should be laid in a mortar composed of one part of Portland cement and two parts of sand, with all joints struck full.



Erection of C-H Vertical Water Tube Boilers and Superheaters, Mark Manufacturing Company, Chicago, Illinois

Care and Operation of Boilers

WATER LEVEL

WHENEVER going on duty in the boiler room, find out, first of all, where the water level is in the boilers. Never unbank nor replenish the fires until this is done. Make sure that the gauge glass and gauge cocks, and all the connections thereto, are free and in good working order. Do not rely upon the glass altogether, but use the gauge cocks also, and try them all, several times a day.

FILLING BOILER

When a boiler has been empty for cleaning or for any other purpose, do not fill it with cold water again until it has become cold. Injecting cold water in a warm boiler will cause the boiler to contract unduly and will probably loosen some of the joints.

TIGHT JOINTS AND GOOD GASKETS

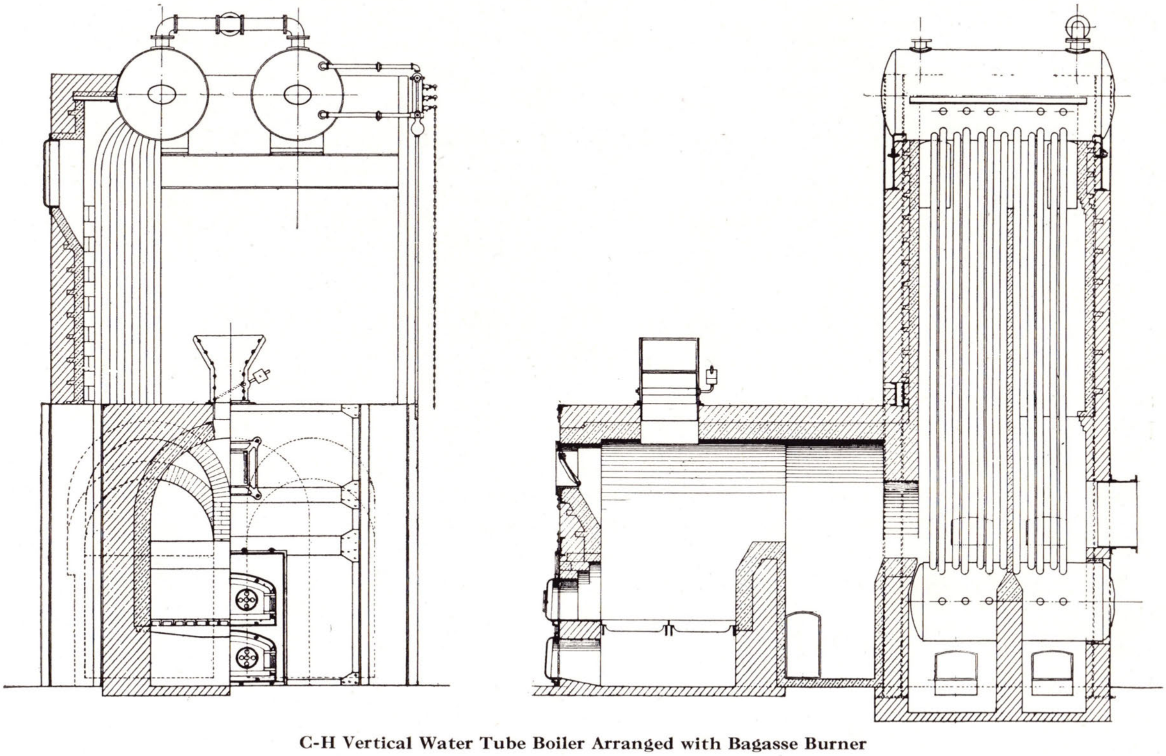
In preparing to get up steam after the boiler has been out of service, be sure that the manhole and handhole joints are tight. Do not use gaskets that are thin and hard. Hard gaskets can be softened by soaking in graphite and oil.

VENTILATING SETTING

When gas or oil is used for fuel, care should be exercised to avoid an explosion resulting from the accumulation in the boiler setting of gas. Never close the damper entirely with fire in the furnace. Do not turn on the fuel supply when starting up or after the snapping out of the burner without first placing in the furnace a dry torch or piece of burning waste to ignite the fuel instantly.

CUTTING IN BOILERS

In firing up a boiler that is to be connected with others that are already in service, keep its stop-valve closed until the pressure within the boiler has become exactly equal to that in the steam main. Then open the stop valve a bare crack, and slowly increase the opening until the valve is wide open. The complete operation should occupy two minutes or more. Close the valve at once if there is the slightest evidence of any unusual jar or disturbance about the boiler. See that the steam main to which the boiler is to be connected is thoroughly drained before the valve is opened.



C-H Vertical Water Tube Boiler Arranged with Bagasse Burner

LOW WATER

In case of low water in the boiler, the fire should be extinguished or smothered in the quickest possible way. If gas or oil is used as fuel, shut off the supply from the burners and close the ash pit doors. Extinguishing the fire can be accomplished, where practical, by throwing a stream of water from a hose on the fire, but in doing this possibly the stream of water will strike the setting walls and boiler, and result in some damage. The smothering of the fire with wet ashes or fresh fuel is the safest, but not quite so efficient. Do not turn on the feed, under any circumstances, to raise the water line, and do not open or close any of the valves until the boiler has cooled off. After a boiler has received such treatment, it should be allowed to thoroughly cool, so that a careful inspection of it can be made. It is best, before putting such a boiler back in service, to give it a hydrostatic test to develop any weakness or leaks that have resulted from overheating.

REPAIRS UNDER PRESSURE

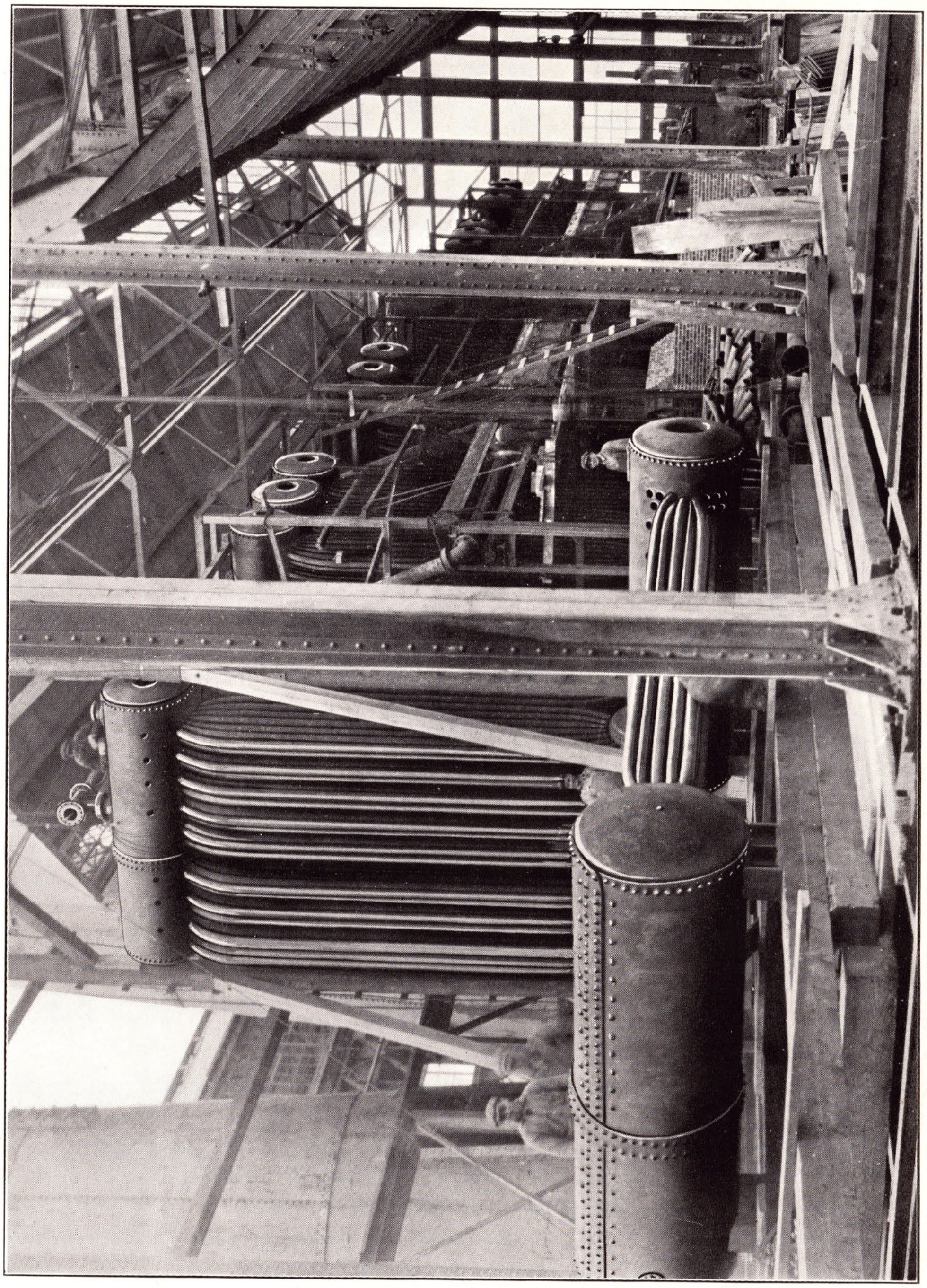
In case of leaks in boilers and boiler connections, no repairs should be attempted while the pressure is on. This applies to caulking seams in boilers, tightening up bolts in flanged joints, as well as to repairs of any kind whatsoever.

FOAMING

Foaming is usually caused by organic matter in suspension in the water. For temporary relief, close the throttle and open the fire doors for a few minutes, when the water will usually settle and the proper level may be ascertained. After determining the water level, if it is sufficiently high, blow down some of the water in the boiler and feed in some fresh water. Repeat this several times if necessary. Surface blowing will prevent foaming to a certain extent. As a premanent prevention, the water may be filtered, or, in case of small plants, the use of settling tanks may be found practical and satisfactory.

SAFETY VALVES

The safety valves should be tried each day—that is, they should blow once each day, or the valve lever should be raised by hand, to see that the valve does not stick. The most satisfactory method in small plants is to raise the pressure of the boiler sufficiently to cause the safety valve to blow, at which time the steam gauge should indicate the pressure at which the valve is set. In large plants this method would result in considerable waste of steam and the valve lever can be raised by hand to determine whether it is stuck, or facilities may be provided for removing the safety valves and steam gauges from the boilers for testing them. A safety valve should never be set higher than the pressure allowed by the insurance company's policy or by permits issued by inspectors operating under local laws or ordinances. No stop valve should be in the connection between the safety valve and the boiler.



Erection of six 750 H.P. C-H Vertical Water Tube Boilers in Large Sugar Central in South America

BLOW-OFF

Expansion and contraction of the blow-off pipe should never be restricted by brick work. Blow-off valves, even with the best quality of feed water, should be opened each morning before the water has started to circulate in the boiler. Do not open the valve with a jerk, as it is liable to let go and result in a serious accident. Open it slowly so as to avoid shocks from water hammer action. It should remain open for only a short time until it is seen that the accumulation of all foreign matter in the water that will pass out has done so.

PRIMING

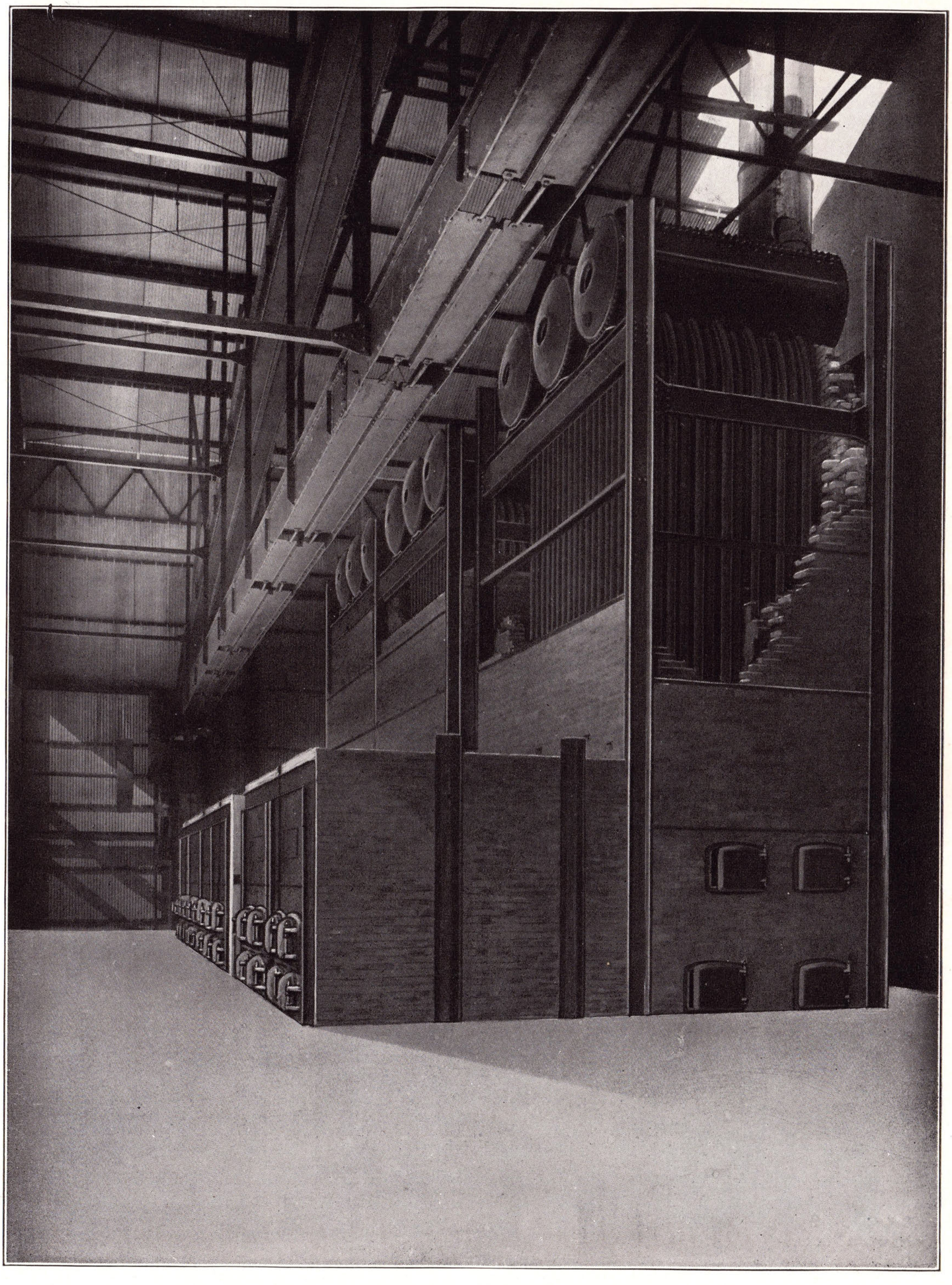
Priming may sometimes be stopped by lowering the water level. When caused by excessive concentration of salts within the boiler, it may be largely overcome by blowing down. Where salts exist in such large quantities that the boiler has to be blown down so frequently it results in big loss, the best remedy is to secure some other feed water supply. In some instances, the salts may be taken care of by treating the water. The selection of a water treatment should in all cases be submitted to some authority.

INTERNAL CLEANING

An engineer should find out for himself how often his boilers need to be opened and cleaned. The efficiency and capacity of a boiler are dependent on the cleanliness of the heating surface. The extent of the influence of scale on the efficiency and capacity of a boiler is realized by very few. Mr. Hutton, in his book, "Steam Boilers," gives the following table showing loss of fuel due to the presence of scale in boilers:

Scale 1-64″ thick causes a loss of 2 per cent of fuel.
Scale 1-32″ thick causes a loss of 4 per cent of fuel.
Scale 1-16″ thick causes a loss of 9 per cent of fuel.
Scale 1-8″ thick causes a loss of 18 per cent of fuel.
Scale 3-16″ thick causes a loss of 27 per cent of fuel.
Scale 1-4″ thick causes a loss of 38 per cent of fuel.
Scale 3-8″ thick causes a loss of 48 per cent of fuel.
Scale 1-2″ thick causes a loss of 60 per cent of fuel.
Scale 5-8″ thick causes a loss of 74 per cent of fuel.
Scale 3-4″ thick causes a loss of 90 per cent of fuel.

Not only are the efficiency and capacity greatly reduced, but the tubes are burned out when a coat of scale or film of oil prevents the water from coming in contact with them. If the life of the tubes is too short, it is evidence that they contain a film of oil or coat of scale, or have been subjected to a blow pipe action of the flames from the furnace. Blow pipe action is not liable to occur except when stokers or forced draft are used and the fire bed is allowed to get too thin.



Erecting 2500 H.P. of C-H Vertical Water Tube Boilers, in the Plant of
Carpenter-O'Brien Company, Jacksonville, Fla.

Cylinder oil should be kept out of boilers. It will cause overheating of tubes and plates. It can be removed from the boiler by scraping and scrubbing and also by the introduction of soda ash or carbonate of soda in the boiler. This internal agent should be boiled in the boiler ten or twelve hours, after which the boiler should be cooled down, emptied and washed out with cold water.

SCALE

When incrustation is the result of carbonates of lime or magnesia, the feed water should be heated or treated by barium carbonate. The same treatment is recommended when the incrustation is caused by the presence of sulphite of lime.

Methods for preventing corrosion consist of using carbonate of soda, alkali, caustic soda and heating feed water and keeping air from feed. Before using any of the remedies, it should first be determined the cause of the corrosion and the correct remedy applied.

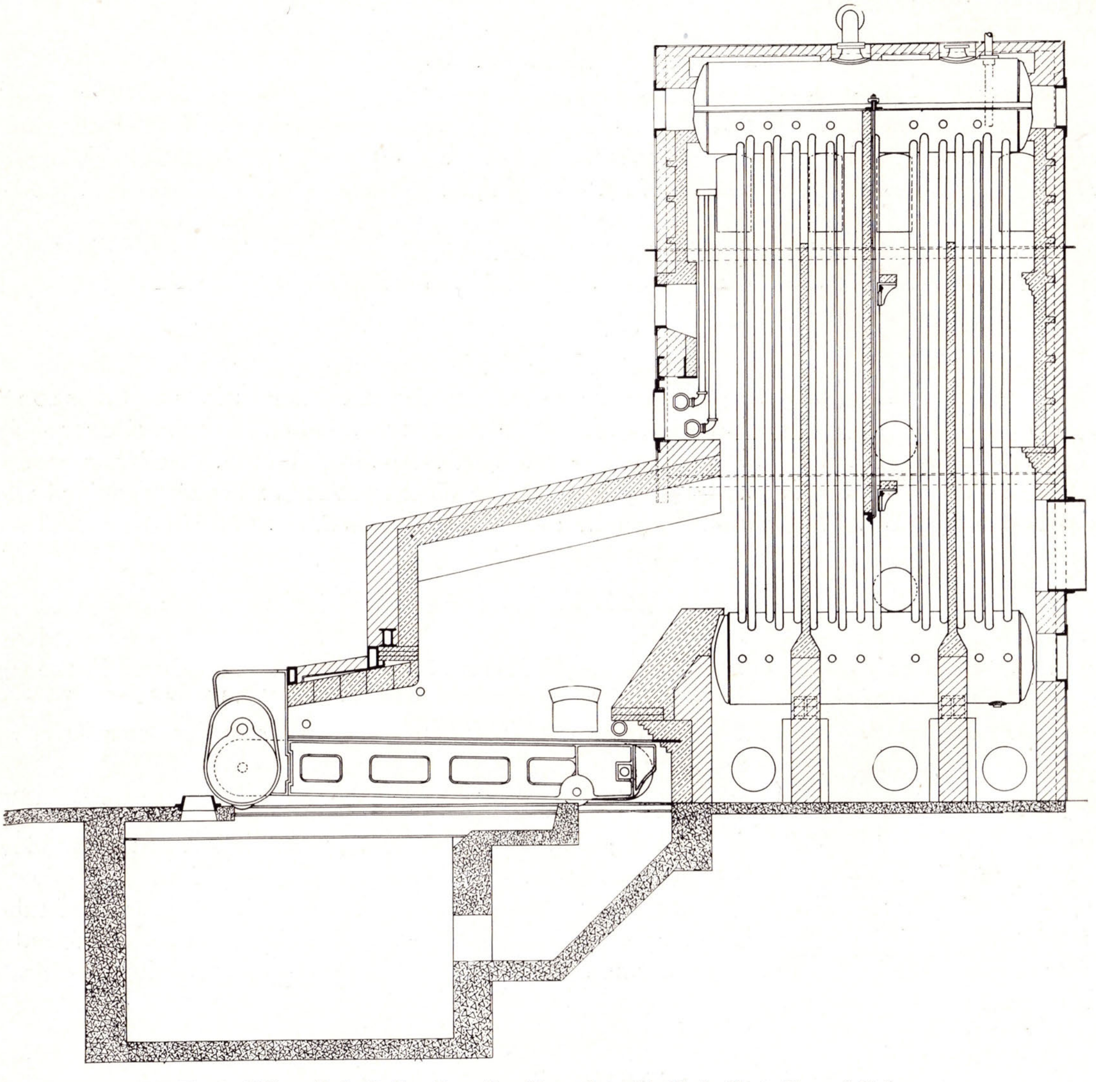
Boiler compounds are not recommended for scale that has already formed in a boiler, except soda ash or carbonate of soda may be used for softening very hard incrustations on tubes so that they can be removed by tube cleaners, but immediately after softening, the tube cleaner should be used, as the contact of the air has a tendency to harden the incrustation. Boiler compounds are very useful as preventatives, but should never be used until it has been determined what compound is suitable. The water should be analyzed by a chemist and his recommendation should be obtained as to the compound to be used.

For cleaning the tubes internally, it is best to use an air driven or water driven turbine cleaner. Where water can be had under constant pressure, the cleaner can be connected to a pump. When the air driven cleaner is used, a stream of water should be introduced in the tube to keep the cutters of the cleaner cool and to wash out the scale as it is chipped off. In cases where the accumulation is of excessive thickness, it can be softened by the use of soda ash or carbonate of soda, as explained above.

In The Casey-Hedges Company Horizontal Water Tube Boilers, sediment and mud will have a tendency to accumulate in the bottom of the back header, where it can be readily blown off or removed through the bottom handholes. The greatest amount of accumulation in the horizontal type of boiler will be in the bottom of the headers and in the lower rows of tubes, and these parts of the boiler should be examined most frequently. Where they are found to be free of scale and foreign matter, it is safe to conclude that the upper rows of tubes are also in a clean condition.

EXTERNAL CLEANING

The outer surface of the tubes of the water tube boilers should be cleaned of soot at frequent intervals in cases where more or less carbon monoxide leaves the boiler furnace and adheres to the tubes. This cleaning is done by means of a steam lance or stationary soot blower. Cleaners are inserted in the boiler setting through small doors provided for the purpose, and the cleaner



C-H Vertical Water Tube Boiler, Four Pass Type, Set with Chain Grate Type of Stoker oscillated so that all sections of the setting are reached, or through hollow staybolts in the headers. Where stationary blowers are installed, they should be examined periodically to detect any leaks that might develop. Leaking of water or condensation on the boiler tubes will result in corrosion, or, if in contact with the brick work, will cause disintegration of the setting. Avoid soot and ash pockets in the boiler setting. Ashes contain more or less sulphur, which, if in constant contact with metal, will result in rapid corrosion. At frequent periods, a man should go inside of the boiler setting, both above and below the tubes, and examine it for soot and ashes. The setting should be kept clean of accumulations of this character. The ash pit should also be cleaned frequently. Large accumulations of ashes in the ash pit prevent air from coming in contact with the grates, resulting in their burning. This will have to occur only one time to destroy a set of grates. It is good practice to have a depressed, water tight ash pit, and keep water in it. The evaporation of this water will act as a very effective agent in preserving the life of the grates, and relieve the tendency for coal to clinker.

COOLING OFF

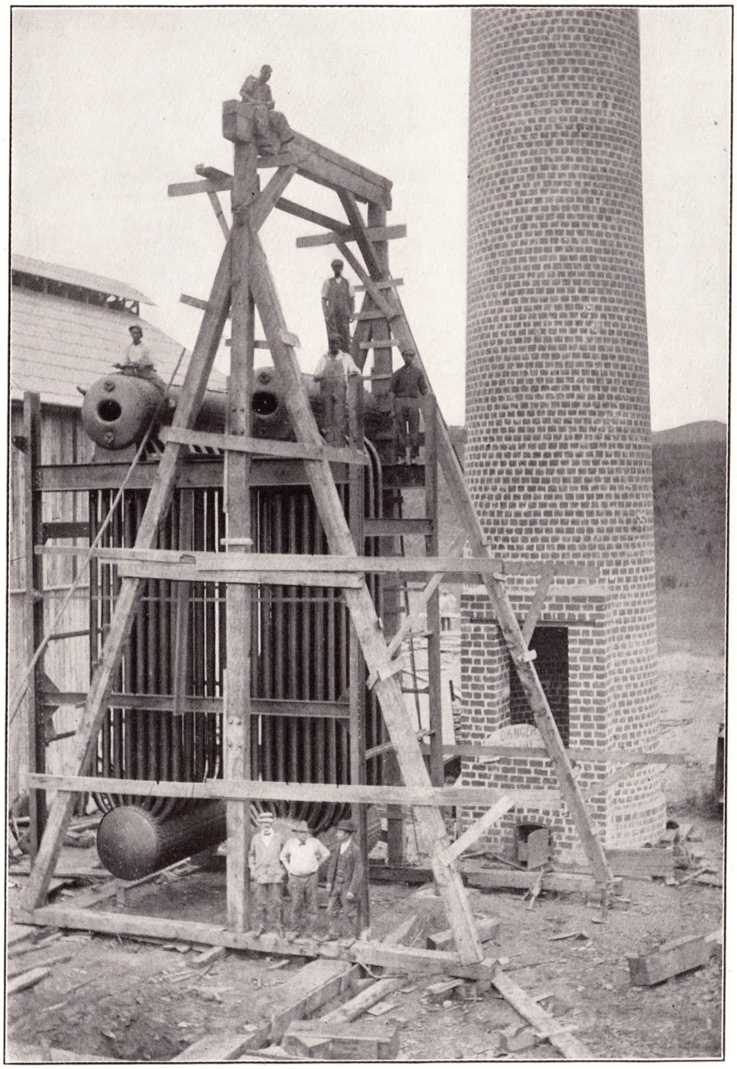
In cooling a boiler for cleaning, first let the fire die out, then close all doors and leave the damper open until the pressure falls to a low point, or bring the pressure to a low point by banking or smothering the fires and allowing the boiler to cool gradually. Do not empty the boiler of water until the boiler setting has become cool. A hot setting around an empty boiler will loosen the rivets and tube joints, and after such abuse a boiler will leak.

BOILER SETTING

Boiler settings should be examined frequently to detect cracks and air leaks. This can be done by passing a torch over the surface of the setting and if any air leaks exist the flame will be drawn towards the setting. Any cracks or air leaks in the setting should be pointed up with mortar or plastic material of some kind. Examine the baffles in the boiler periodically to see that they have not been knocked out of position. This is a frequent occurrence in the case of horizontal baffles when the steam lance is used for cleaning and examinations of the baffles of this type should be made very frequently. In renewing the tubes in vertical baffle boilers, if baffles are knocked out of position, they should be replaced and made gas tight. When repairs are made to the inside of a boiler setting, such as renewing the brick lining, a gas tight joint should be made between the baffles and the side walls of the setting.

LAYING UP BOILERS

Before laying up boilers, they should be thoroughly cleaned both inside and outside. After washing the boiler thoroughly, let it drain well. See that no moisture can collect anywhere about the boiler or drip on it internally or externally. Leave the handhole and manhole covers off so that air will be free to circulate through the boiler. Examine the boiler setting carefully and blow or sweep the surface clean of ashes and soot.



Erection of two 200 H.P. Boilers with Furnaces for Burning Spent Tan,
Transylvania Tanning Company, Brevard, N. C.

The Metric Sytem of Weights and Measures

IN the Metric System, the meter is the base of all the weights and measures which it employs.

The Meter is the primary unit of length and was intended to be one ten-millionth part of the distance, measured on a meridian of the earth, from the equator to the pole and equals about 39.37 inches.

Upon the Meter are based the following primary units: the Square Meter, the Are, the Cubic Meter or Stere, the Liter and the Gram.

The Square Meter or Centare is the unit of measure for small surfaces.

The Are is the unit of land measure; this is a square whose side is ten meters in length, and which contains one hundred square meters or centares.

The Cubic Meter, or Stere, is the unit of volume; this is a cube whose edge is one meter in length.

The Liter is the unit of capacity; this is the capacity of a cube whose edge is one tenth of a meter, that is one decimeter in length.

The Gram is the unit of weight; this is the weight of distilled water at 4 degrees. Centigrade, contained in a cube whose edge is one hundredth part of a meter.

From these primary units the higher and lower orders of units are derived decimally as follows:

SCHEME OF THE WEIGHTS AND MEASURES OF THE METRIC SYSTEM

RATIOS	LENGTHS	SURFACES	VOLUMES	WEIGHTS
1,000,000				Millier or Tonneau
100,000				Quintal
10,000	Myriameter			Myriagram
1,000	Kilometer		Kiloliter	Kilogram, or Kilo
100	Hectometer	Hectare	Hectoliter	Hectogram
10	Dekameter		Dekaliter	Dekagram
1	Meter	Are	Liter	Gram
0.1	Decimeter		Deciliter	Decigram
0.01	Centimeter	Centare	Centiliter	Centigram
0.001	Millimeter		Milliliter	Milligram

It will be seen from this table that ten millimeters equal one decimeter, ten centimeters equal decimeter and so on.

Multiples and sub-multiples of the units, meter, liter and gram are expressed by the prefixes.

Deka equals	10	Deci equals	0.1
Hecto equals	100	Centi equals	0.01
Kilo equals	1000	Milli equals	0.001

METRIC AND U. S. CONVERSION TABLE

MEASURES OF LENGTH

Metric to English

millimeter	0.03937 inch
centimeter	0.3937 inch
meter	39.37 inches
1 meter	3.2808 feet
1 kilometer	0.6214 mile

English to Metric

1 inch	25.4 millimeters
1 inch	2.54 centimeters
1 inch	0.0254 meter
1 foot	0.3048 meter
1 mile	1.609 kilometers

MEASURES OF SURFACES

Metric to English

1 sq. millimeter	0.00155 sq. inch
1 sq. centimeter	0.155 sq. inch
1 sq. meter	10.764 sq. feet
1 sq. meter	1.196 sq. yards
1 hectare	2.471 acres
1 hectare	0.00386 sq. mile
1 sq. kilometer	0.3861 sq. mile

English to Metric

1 sq. inch	645.14 sq. millimeters
1 sq. inch	6.452 sq. centimeters
1 sq. foot	0.0929 sq. meter
1 sq. yard	0.8361 sq. meter
1 acre	0.4047 hectare
1 sq. mile	259.00 hectares
1 sq. mile	2.59 sq. kilometers

MEASURES OF VOLUME AND CAPACITY

Metric to English

1 cubic centimeter	0.061 cu. inch
1 cubic meter	35.316 cu. feet
1 cubic meter	1.308 cu. yards
1 liter = 1 cu. decimeter	61.023 cu. inch

English to Metric

1 cu. inch	16.39 cu. centimeters
1 cu. foot	0.0283 cu. meter
1 cu. yard	0.7645 cu. meter
1 cu. foot	28.32 liters

LIQUID MEASURE

Metric to English

1 liter	1.0567 quarts
1 liter	0.2642 gallon
1 cu. meter	264.17 gallons

English to Metric

1 quart	0.9463 liter
1 gallon	3.7854 liters
1 gallon	0.0038 cu. meter

DRY MEASURE

Metric to English

1 liter	0.908 quart
1 hectoliter	2.8375 bushels

English to Metric

1 quart	1.1013 liters
1 bushel	0.3524 hectoliter

WEIGHTS

Metric to English

1 milligram	0.0154 grain
1 gram	15.432 grains
1 kilogram	2.2046 lbs. (avoir.)
1 metric ton	1.1023 net tons
1 metric ton	0.9842 gross ton

English to Metric

1 grain	64.80 milligrams
1 grain	0.0648 grain
1 lb. (avoir.)	0.4536 kilogram
1 net ton	0.9076 metric ton
1 gross ton	1.0161 metric tons

COMPOUND UNITS

Metric to English

1 kilogram per meter	0.6720 lb. per ft.
1 kilogram per sq. centimeter	14.223 lbs. per sq. inch
1 kilogram per sq. meter	0.2048 lb. per sq. foot
1 kilogram per cu. meter	0.0624 lb. per cu. foot
1 kilogram-meter	7.233 foot-pounds
1 cheval vapeur (metric H.P.)	0.986 horse power
1 kilo watt	1.340 horse power
1 kilo per cheval	2.325 lbs. per H.P.

English to Metric

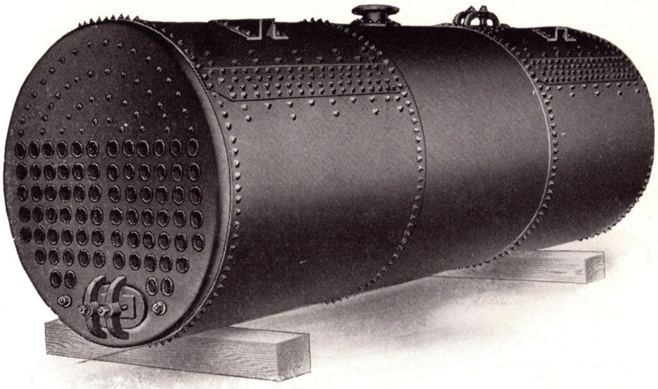
1 lb. per foot	1.4882 kilograms per meter
1 lb. per sq. inch	0.0703 kilo per sq. centimeter
1 lb. per sq. foot	4.8825 kilograms per sq. meter
1 lb. per cu. foot	16.0184 kilos per cu. meter
1 foot pound	0.1383 kilogram-meter
1 horse power	1.014 cheval vapeur (metric H.P.)
1 horse power	0.746 kilo watt
1 lb. per horse power	0.447 kilo per cheval

HEAT INTENSITY

Temp. Centigrade	(temp. Fahr.—32 degrees) 5-9
Temp. Fahrenheit	(temp. Cent. X 9-5) plus 32 deg.

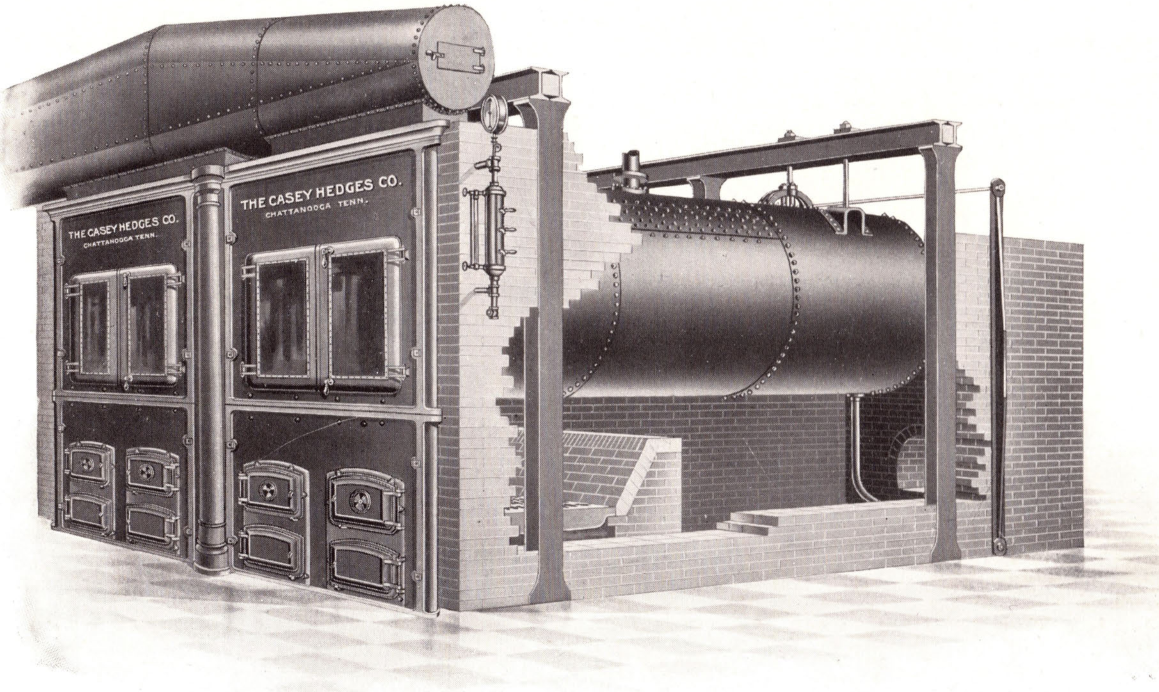
HEAT QUANTITY

A kilogram calorie	3.968 British thermal units
A pound calorie	1.8 British thermal units
A British thermal unit	0.252 kilogram calorie
A British thermal unit	0.555 pound calorie

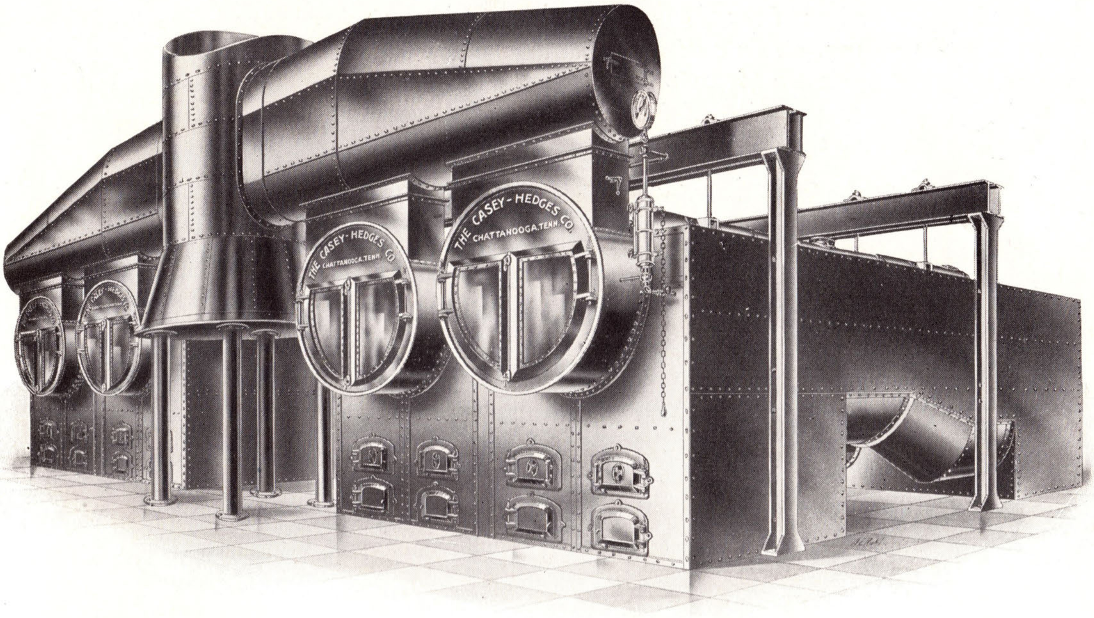


C-H Horizontal Return Tubular Boiler

WE issue a special catalog describing the C-H High Pressure Horizontal Return Tubular Boiler. The same skill and care are used in the construction of our Return Tubular Boilers as are used in the manufacture of the C-H Water Tube Boilers. These boilers are built in sizes ranging from 50 to 300 horsepower in accordance with the A. S. M. E. Code or other special requirements and are built for 125 and 150 pounds safe working pressure. Special attention is given to the design of the settings to suit fuel conditions, etc. Return Tubular Boilers are preferably set with the Beam and Column Suspension as shown below.


THE CASEY HEDGES CO.
CHATTANOOGA TENN.
THE CASEY HEDGES CO.
CHATTANOOGA TENN.

Two Horizontal Return Tubular Boilers
With Full Flush Front, I Beam and Column Suspension


THE CASEY-HEDGES CO. CHATTANOOGA, TENN.
THE CASEY-HEDGES CO. CHATTANOOGA, TENN.

The C-H Steel Casing

THE PERFECT BOILER SETTING

THE Steel Casing Boiler Setting for Tubular Boilers was first manufactured and perfected by our company. While numerous imitations have been placed on the market, they have always lacked in some essential feature—being in most instances merely attempts to copy construction from our illustrations. The buying public should remember that we control the only patents ever issued covering the steel casing construction, and that we are constantly improving and experimenting. A purchase from us is assurance that you will get the very latest in engineering practice.

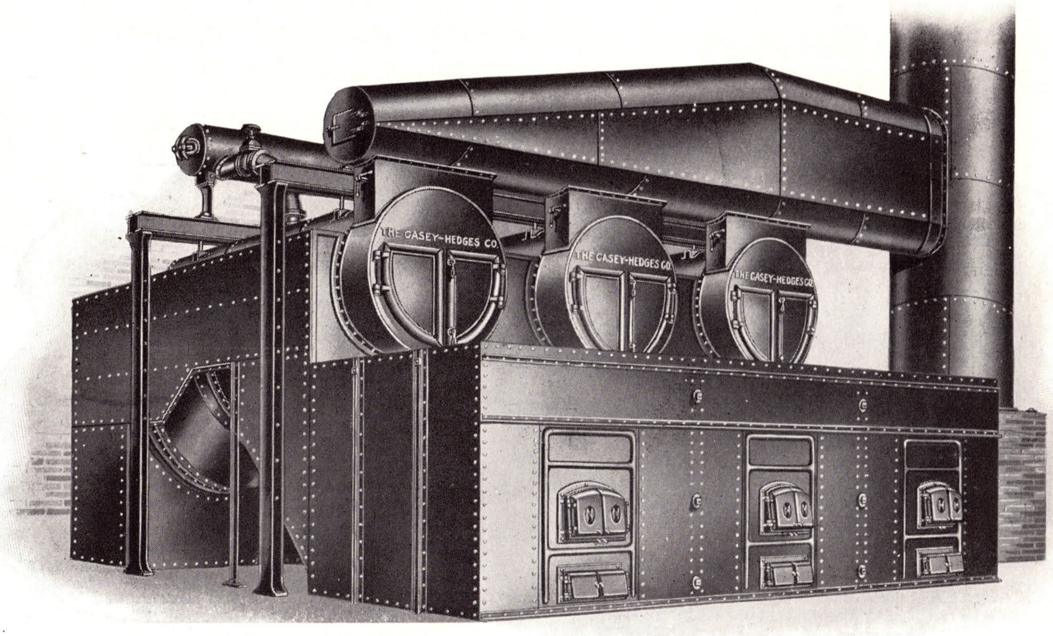
We have perfected the following types of Steel Casings: The Standard type, the Full Dutch Oven type, and the Semi or Half-Dutch Oven type.

Casings of our latest construction are fitted with our Taper Drop Back Combustion Chamber, on which we have patents pending, and we will exercise exclusive control of this feature.

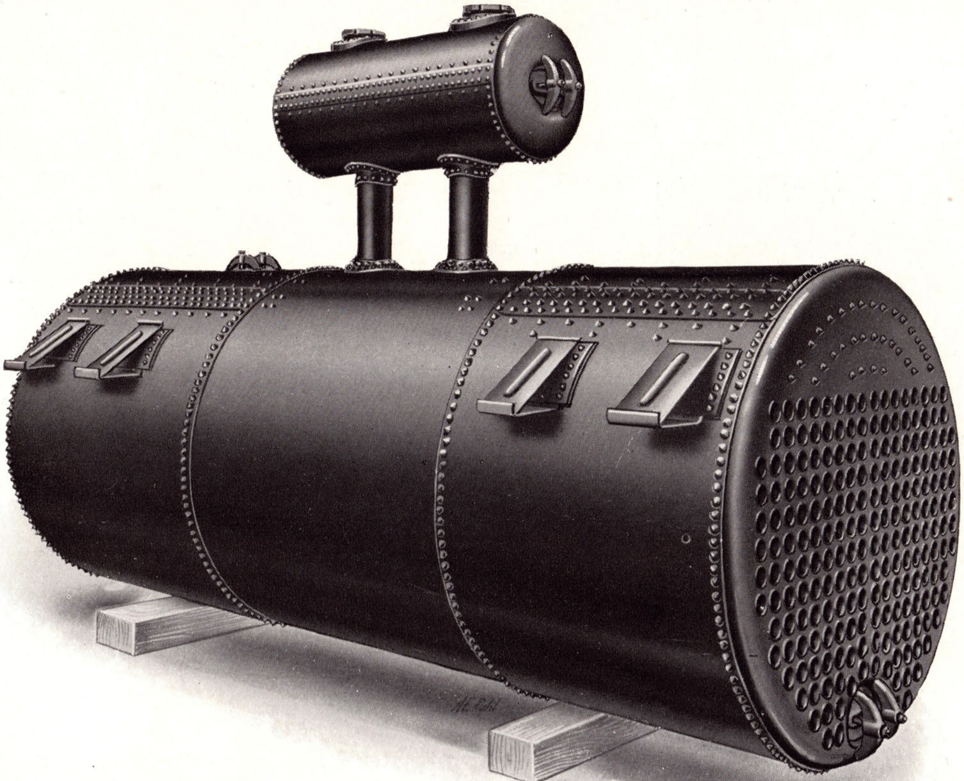
We usually recommend and furnish the C-H Stuffed Back Arch Bar, which is another distinctive Casey-Hedges feature, in connection with our Steel Casing Setting. The C-H stuffed back arch bar is lined with fire brick, so the brick only is exposed to the flame and the bar is practically indestructible.

The enormous success of the C-H Patented Steel Boiler Casing is due to the perfect results obtained through its use. This method of setting boilers will readily appeal to the thoughtful purchaser as being the acme of perfection. Its low first cost, neat appearance, freedom from repairs, economy in consumption of fuel, and increased boiler efficiency have been the means of its finding favor with the largest manufacturing institutions in the country.

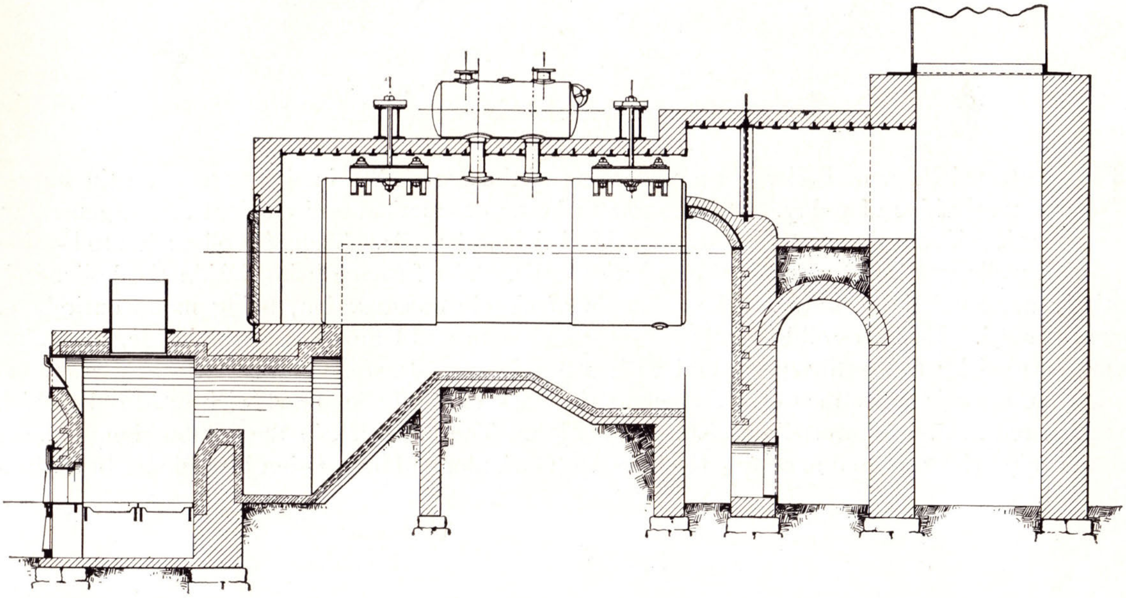
Our Steel Casing has practically overcome all the inherent defects of the antiquated brick setting. A plant to be modern must now have its boilers set in this manner. That the steam using public has so long contended with the many defects of the brick set boiler is remarkable. The losses resulting from the use of the latter would many times pay the National debt. The advent of the air tight steel casing marked the disappearance of the necessity for heavy brick side walls which are a source of annoyance and expense. With the steel casing there is no more crumbling and cracking of heavy walls due to the strains of expansion and contraction to be repaired with expensive delays. Leaky brickwork means low furnace temperature, increased fuel expense, decreased boiler efficiency. Experience has borne out the fact that the increased consumption of fuel due to superfluous air in an ordinary brick setting is enormous. In a number of brick settings tested, the average increase in fuel consumption was 13.6 per cent.


THE CASEY-HEDGES CO.
THE CASEY-HEDGES CO.
THE CASEY-HEDGES CO.

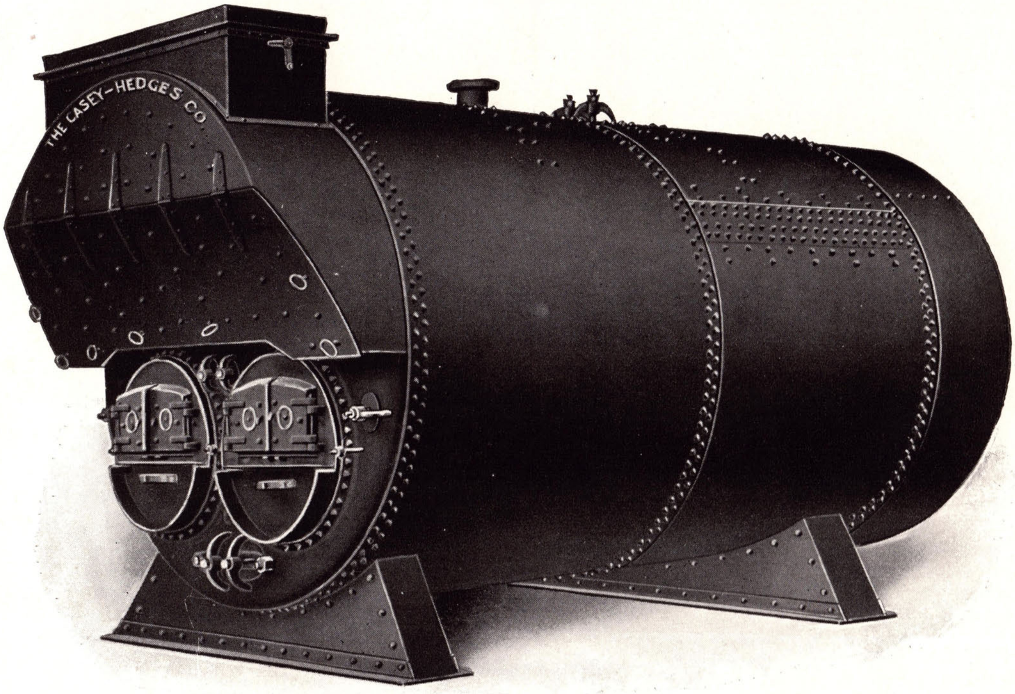
Front View of Improved Steel Dutch Oven Casing with Taper Drop Back Combustion Chamber and Rear Spark Catcher



Special Return Tubular Boilers for Sugar Centrals



The above illustrates what we term our Cuban type of sugar house boiler, this being the type generally used in tropical countries for sugar centrals. We issue a special fifty (50) page catalogue describing sugar house boilers and bagasse burners.



Internal Furnace Boilers

THE Internal Furnace Boiler is a modification of the Scotch Marine boiler used on the largest ocean steamships of today. It is known to be an economical and efficient steam generator. The boiler is self contained. It is not incased in brickwork walls. There is no loss due to heating up brick walls or filtration of air through the walls. The furnace being inside the boiler it is entirely surrounded by water. The boiler is of simple construction, being made entirely of wrought steel. It is accessible for cleaning through man and handholes to the inside, the tubes being cleaned by the ordinary method with a flue brush. It will be noted from the sectional view that there is a combustion chamber in the back of the boiler lined with fire brick, which becomes red hot and materially assists combustion. The fire brick in the combustion chamber are the only brick required in setting the boiler. The boiler will burn either bituminous or anthracite coal.

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